Former Quaker State / Ergon Refinery
Newell, West Virginia

Revised Corrective Measures Study Report

August 2019 Project Number: 60595266

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Revised Corrective Measures Study Report

Prepared for
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Acronyms

°C	degrees Celsius
%RE	percent reference emitter response
µg/dL	micrograms per deciliter
µg/L	micrograms per liter
AECOM	AECOM Technical Services Inc.
AOC	Areas of Concern
API	American Petroleum Institute
AST	aboveground storage tank
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAO	Corrective Action Objectives
CMS	Corrective Measures Study
CoC	chain of custody
COC	constituent of concern
COI	constituent of interest
DAF	dissolved air flotation
DO	dissolved oxygen
EFR	enhanced fluid recovery
EI	Environmental Indicators
EPA	U.S. Environmental Protection Agency
EWVI	Ergon West Virginia Inc.
ft/ft	feet per foot
gpm	gallons per minute
H_2SO_4	sulfuric acid
HCl	hydrochloric acid
HHRA	Human Health Risk Assessment
HI	Hazard Index
HNO_3	nitric acid
IM	Interim Measures
IMWP	Interim Measures Work Plan

ITRC	Interstate Technology and Regulatory Council
LBA	Lube Blending Area
LCS	Laboratory Control Spike
LCSD	Laboratory Control Spike Duplicate
LNAPL	light nonaqueous phase liquid
MCL	maximum contaminant level
MEK	methyl ethyl ketone
mg/L	milligram per liter
mL	milliliter
MNA	Monitored Natural Attenuation
MS	matrix spike
MSD	matrix spike duplicate
msl	mean sea level
MTBE	methyl tertiary-butyl ether
mV	millivolts
NAPL	nonaqueous phase liquid
NFA	No Further Action
NA	natural attenuation
ND	non-detect
NSZD	Natural Source Zone Depletion
PAH	Polycyclic Aromatic Hydrocarbons
PID	photoionization detector
PH	petroleum hydrocarbons
POC	points of compliance
PTFE	polytetrafluoroethylene
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QS	Quaker State Company
RA	Risk Assessment
RBC	Risk Based Concentration

RCRA	Resource Conservation and Recovery Act
redox	oxidation/reduction potential
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RSL	regional screening level
SCAV	scavenger (wells)
SG	soil gas (sampling points)
SOPUS	Shell Oil Products United States
SI	Site Inspection
SOP	Standard Operating Procedure
SPL	separate-phase liquid
SS	sub-slab (sampling points)
SWMU	Solid Waste Management Units
TEAs	terminal electron acceptors
TI	Technical Impracticability
TIE	Technical Impracticability Evaluation
TR	Target Risk
UVOST®	Ultraviolet Optical Screening Tool®
VOA	volatile organic analyte
VOC	volatile organic compound
VSI	Visual Site Inspection
WV	West Virginia
WVDEP	West Virginia Department of Environmental Protection
WWTP	Waste Water Treatment Plant

Certification Statement

I certify that the information contained in or accompanying this Corrective Measures Study Report are true, accurate, and complete to the best of my knowledge.

As to the portions of this report for which I cannot personally verify their accuracy, I certify under penalty of law that this report and any attachments were prepared in accordance with procedures designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person responsible for gathering the information, or the immediate supervisor of such person(s), the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Signature: D. T. Kirk

Name: D. T. Kirk on behalf of SOPUS Products

Title: Principal Program Manager

Date: 8-21-19

1 Introduction

A Resource Conservation and Recovery Act (RCRA) Corrective Measures Study (CMS) was performed for the former Quaker State Company (QS)/Ergon of West Virginia (WV) Refinery located on State Route 2, Newell, WV (hereafter called the “Refinery” or “facility”). The CMS and this Report were prepared by AECOM Technical Services, Inc. (AECOM) on behalf of the Pennzoil Quaker State Company dba SOPUS Products (hereby referred to as Shell). The preparation and submittal of this CMS comply with requirements of the existing U.S. Environmental Protection Agency’s (EPA) Administrative Order Docket No. RCRA-III-074-CA (referred to herein as the Order) dated February 1994. This CMS report follows Tasks I through III of the EPA CMS scope of work guidance document (EPA, 2011a) for the subject Refinery to address the current environmental conditions identified under the RCRA corrective action process. Information and guidance provided in the EPA’s Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action (EPA, 2004) and Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration (EPA, 1993) were also incorporated into this CMS, where applicable. The submission of an acceptable CMS is the last task identified for Shell under the Order.

1.1 Corrective Measures Approach and Site-Specific Purpose

The purpose of the CMS portion of the RCRA corrective action process is to identify, evaluate, and propose remedial technologies and alternatives for addressing constituents of concern (COCs) that exist in site media affected from various releases that have occurred during site operations at the Refinery. This report uses data acquired from the RCRA Facility Investigation (RFI), interim measures (IM), and subsequent groundwater monitoring events that were documented in existing project reports.

The CMS is designed to address the following objectives:

- Summarize site environmental conditions and previous interim remedial action results;
- Define Corrective Action Objectives (CAOs) for affected site media;
- Discuss whether achieving drinking water standards associated with final groundwater goals is technically impracticable for groundwater;
- Identify potential remedial and/or institutional/engineering control measures for groundwater that contains dissolved COCs above established action goals and for separate-phase liquid (SPL) in the subsurface;
- Assemble potential measures into corrective measure alternatives including a possible alternative remedial strategy;
- Screen the corrective measure alternatives to retain potential effective and feasible alternatives;

- Evaluate and compare the retained potential alternatives using specific screening criteria and CAOs;

- Select the recommended corrective measure alternatives to address the affected media.

1.2 Report Organization

This CMS is organized into eight sections.

- **Section 1.0** presents the introduction, a summary of the CMS objectives, the purpose of the CMS, site background, and history and current regulatory status of the site.
- **Section 2.0** presents information about the site geology and hydrogeology, affected groundwater, presence of SPL, results of completed risk assessment (RA), and a summary of conducted interim remedial actions.
- **Section 3.0** summarizes the corrective action objectives as they pertain to the applicable federal and state remediation criteria.
- **Section 4.0** is a Technical Impracticability Evaluation (TIE) for site groundwater.
- **Section 5.0** identifies potential corrective measures alternatives including alternative remedial strategy concepts. This section is further organized to present remedial alternatives by media.
- **Section 6.0** presents the screening and evaluation process of potential corrective measures alternatives.
- **Section 7.0** presents the recommendations of the selected corrective measures alternatives.
- **Section 8.0** presents the CMS reporting process.
- **Section 9.0** presents the references used in this document.

1.3 Site History, Facility Location, Operation, and Surrounding Uses

The facility now known as Ergon West Virginia, Inc., Newell Refinery was initially called the Congo Refinery when it was owned by QS. On February 18, 1994, the EPA Region 3 executed the Order for the QS Congo Refinery at Newell, WV. QS sold the property to Ergon Inc. on July 19, 1997, and Pennzoil merged with QS in 1999. Shell acquired Pennzoil-QS in 2002 and began dba SOPUS Products (Shell) in 2003. Shell continues to execute activities associated with the current Order, including the annual groundwater monitoring program.

The Refinery is located in Hancock County, West Virginia, near the town of Newell (**Figure 1-1)**, and it occupies approximately 70 acres along the southern bank of the Ohio River, approximately 1.5 miles southwest of the town of Newell. The Refinery is bordered to the north and northwest by the Ohio River and to the south by State Route 2 and railroad tracks.

The facility comprises an administration building and several distinct buildings as well as equipment used for the processing and storage of petroleum products. The Refinery was designed and constructed from 1970 to 1972. Operations at the Refinery commenced in April 1972.

The Refinery's main operations conducted formerly by QS and now Ergon Inc. involve the refining of crude oil and distribution of petroleum products. Manufacturing processes used at the Refinery include the following:

- Storing crude oil and product using tanks of varying sizes
- Desalting and distillation processes whereby crude oil is purified and broken down into different fractionations
- Reforming low-octane gasoline into high-octane gasoline
- Extracting propane from vacuum tower bottoms
- Hydrotreating lube oil stocks
- Removing wax from lube oil stocks
- Blending gasoline with additives to meet quality specifications

Raw materials used in the refining operations include crude oil, lube oil additives, and gasoline additives. Crude oil arrives at the Refinery primarily by barge. A small amount of crude oil arrives by truck, and additives are delivered to the Refinery by rail or truck. The site has multiple tank storage areas, loading racks, substations, storage areas, warehouses, maintenance and control buildings, fabrication shops, a laboratory, two docks, and a methyl ethyl ketone (MEK) dewaxing unit and ketone stripper. Additionally, process pipe-ways and an oily water sewer traverse through the entire site.

In addition, Shell leases a portion of the property (the Lube Blending Area [LBA] / package plant) that operates under the RCRA West Virginia Permit WVD057634776. The Shell-leased property is approximately 17 acres and located in the south east portion of the site, where it is bordered to the west by railroad tracks and to the north by Tank Area 7A. The Shell-leased area contains the canning and bottling plant, the LBA, substations, storage and maintenance buildings, and multiple small tank storage areas.

The area surrounding the Refinery is rural and sparsely populated. The total population of Newell and surrounding communities is approximately 1,400 people (Census 2010). In the vicinity of the Refinery, land use is primarily low-density industrial and residential. Two residential properties are located east of the Refinery. In addition, industrial properties immediately border the Refinery to the east along State Route 2; these include SH Bell Company and CE Minerals Processing Inc.

1.4 Regulatory History and Status

1.4.1 Summary of RFI SWMUs and AOCs

An initial Site Inspection (SI) was performed by NUS Corporation in 1987. In 1988, Versar, Inc., a subcontractor to Camp, Dresser and McKee, and on behalf of the EPA, conducted a Visual Site Inspection (VSI) of the Refinery and subsequently prepared a *RCRA Facility Assessment (RFA) Report* (Versar 1989). The RFA Report identified Solid Waste Management Units (SWMUs) and potential Areas of Concern (AOCs) at the Refinery. For the purpose of the CMS, the SWMUs and AOCs identified in the RFA have been listed below; however, many of the identified SWMUs previously received No Further Action (NFA) decisions. The SWMU and AOC designations are as follows:

RFA SWMU	SWMU DESCRIPTION
1	Plant Boilers
2	Ketone Steam Stripper
3	Solvent Tank Area
4	Satellite Storage Area
5	Used Solvent Sump
6	Old Heat Exchanger Cleaning Pad
7	Tank Bottoms Disposal Area No. 4 and No. 6
8	New Heat Exchanger Cleaning Pad and Drum Cleaning Area
9	Old Drum Storage Area
10	Extended Earthen Digestion Basin (Earthen Digested Sludge Holding Basin)
11	API Separators
12	API Separator Solids Tank
13	Equalization Basin (Stormwater Retention Basin)
14	Dissolved Air Floatation (DAF) Separators/DAF Scum Tanks/DAF Scum Sump
15	Aeration Basin
16	Clarifiers
17	Sludge Digestion Basin
18	Sand Filters/Dirty Backwash Water Basin/Filtrate Clearwell
19	Oily Wastewater Sewer System

RFA AOC	AOC DESCRIPTION
1	Tank Areas
2	Process Pipe-ways
3	Old Effluent Holding Basin
4	Site Air Emissions

Gray area = SWMU/AOC has received NFA determination

Figure 1-2 provides a plan view of the Refinery and the SWMU and AOC locations. The 19 SWMUs and four AOCs are identified and described in the Description of Current Conditions Section of the *RFI Work Plan* (HMI, 1998).

SWMUs 2, 3, 5, and 13-18 and AOCs 3 and 4 all received NFA determinations from the EPA. Subsurface soil in SWMUs 2, 3, 5, 13, 14, 15, 16, 17, and 18 have received an NFA. The NFA requests were submitted and approved on the following dates:

- The NFA request for SWMUs 13 and 15 was submitted in the Aeration Basin Equivalent Closure Data Report on July 15, 1999 (HMI, 1999) and received EPA approval on March 14, 2002.
- The NFA request for SWMUs 14, 16, 17, and 18 was submitted in the No Further Action Determination Request SWMUs 14, 16, 17, and 18 Letter on February 11, 2009 (URS, 2009a) and received EPA approval on June 19, 2009.
- The NFA request for SWMUs 2, 3, and 5 was submitted on August 28, 2009 (URS, 2009d) and received EPA approval on October 14, 2009.

Per direction of EPA to Shell/AECOM, the conditions and potential concerns of the remaining SWMUs and AOCs were to be addressed with the results of the various components of the RFI process to be performed at the Refinery. In addition, the EPA stipulated that the groundwater below these SWMUs and AOCs did not receive NFA and should be investigated as site-wide groundwater via the RFI process, including an additional groundwater monitoring program.

The tasks and activities of the RFI were planned and implemented to address the potential concerns of regulated substances in the soil and groundwater of the SWMUs and two AOCs that have no NFA decisions. Soil and groundwater samples were collected and analyzed for site-related constituents in the areas of the SWMUs and AOCs. In addition, the interim remedial measures and groundwater monitoring performed since 2000 provided data to further evaluate the site-wide groundwater conditions and presence of SPL for the remaining SWMUs and AOCs.

The 2009 RFI report concluded low levels of petroleum volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs) existed in site soils that were consistent with constituents associated with crude oil and refining processes. Therefore, as part of the RFI of the site, a human health risk assessment (HHRA) was conducted to determine whether the few COCs identified in site soil at the remaining SWMUs and AOCs were an actual concern that would warrant further investigation or action; the HHRA also assessed the site-wide groundwater conditions including beneath the remaining SWMUs and AOCs.

1.4.2 Summary of Previous Investigations and Reports

Previous activities conducted as part of the environmental program related to former Quaker State activities at the Refinery include the following:

- *Interim Measures Work Plan and Interim Measures Monitoring*: Prepared and initially submitted by HMI in May 1994. Received EPA approval in September 1994.

- Quarterly groundwater monitoring was completed at the site from 1994 to May 2014. Results of the groundwater monitoring were submitted in quarterly monitoring reports to the EPA. In 2015, groundwater monitoring was modified from quarterly to annual.

- *Proposed MW-5 Area Geoprobe® Investigation:* Prepared and initially submitted by HMI in December 1995. Received EPA approval in December 1996.

- The RFI field program was performed in January 1997 and the results included in the *Draft RFI Report* (HMI, 1998).

- *RCRA Closure Plan for Stormwater Basin*: Initial plan prepared and submitted by HMI on December 13, 1995. EPA approval received in February 1997.

- *Aeration Basin Equivalent Closure Plan*: Initial Plan prepared and submitted by HMI in March 1997. Final EPA approval received in July 1997.

- Stormwater Retention Basin and Aeration Basin Closure Programs: These field and reporting programs were performed from September 1996 to April 1998.

- *Soil Sampling Work Plan, API Separators, and New Heat Exchanger Bundle Cleaning Pad:* Initial plan prepared and submitted by HMI in March 1997. Received EPA approval in July 1997. The field program was performed in July 1997 and the results are included in the *Draft RFI Report* (HMI, 1998).

- *RCRA Facility Investigation Work Plan*: Initial draft prepared by HMI and submitted to the EPA on April 19, 1994. Final approval date March 5, 1998.

- RFI Field Program: Performed by HMI in May and June 1998. Collected soil and groundwater samples consistent with *RFI Work Plan*.

- *Draft RCRA Facility Investigation Report*: This draft report was prepared by HMI and submitted to the EPA on November 3, 1998. Based on EPA review of the document and

PQS concurrence, additional investigation of the facility was proposed under an *RFI Work Plan Addendum*.

- *RCRA Facility Investigation Work Plan Addendum:* Initial draft prepared by Shaw and submitted to the EPA in April 2002. EPA comments were incorporated, and a revised Plan was submitted in August 2003. Final EPA approval was received in February 2004.

- Field work for the RFI Addendum was performed in February 2004 through June 2006.

- A report of the *Supplemental Geoprobe® Data Preliminary Review and Evaluation (2004 Data) and Proposed Locations for Additional Borings and Monitoring Wells* (Shaw, 2005) was submitted to the EPA in May 2005. The proposed drilling locations were approved by the EPA in September 2005 and the field work was implemented in November 2005.

- A *Background Data Evaluation Report* (Shaw, 2006a) summarizing the results of the background soil statistics was submitted to the EPA in June 2006. In addition, a *Request for Industrial Land Use Designation* (Shaw, 2006b) for the facility was submitted to the EPA in October 2006.

- Evaluations of SWMU No. 19 (Oily Water Sewer) have been ongoing as part of the RFI. A *Work Plan for Field Verification of Sewer Manholes and Catch Basins in the Oily Water Sewer System* (Shaw, 2006c) was submitted to the EPA in May 2006, and the field verification was performed in June 2006. Based on the results of the RFI program, “Proposed Locations for Additional Wells” was provided to the EPA as a letter submittal on April 17, 2007 (Shaw, 2007). Approval of the plan was received on September 11, 2007, and the field program was executed in November and December 2007.

- An evaluation of SPL presence was completed in 2008 and documented in a letter report to the EPA (dated December 1, 2008) prepared by URS (URS, 2008). This letter also made recommendations based on the results of the SPL evaluation for modifying of the IMs including changing which wells contained total fluids pumps and reducing the groundwater monitoring frequency of certain wells.

- The *Draft RFI Report* prepared by URS was submitted to the EPA in June 2009 (URS, 2009c). The EPA submitted comments to the report on February 21, 2013. An agreement was made between the EPA and Shell that the comments of the draft RFI report would be addressed by several specific memorandums. Final EPA approval of the RFI Report was received in May 2019.

- On July 12, 2012, URS submitted the *Draft IM Work Plan (IMWP) addendum* to the EPA, West Virginia Department of Environmental Protection (WVDEP), and Ergon for work to delineate SPL in the LBA. Field work was completed in July 2013. Results were presented in the *Lube Blend Area Ultraviolet Optical Screening Tool® (UVOST) Investigation* Report, submitted October 2013.

- To address the EPA's comments on the *Draft RFI Report* regarding groundwater discharge to the Ohio River, the *Evaluation of Potential Groundwater Contaminant Discharge to the Ohio River* Technical Memo was submitted to the EPA, WVDEP, and Ergon on November 20, 2013. On May 9, 2018, the EPA submitted review findings related to the 2013 memo, and a revised memo was submitted on May 28 2019. EPA approval of the revised memo was received on May 29, 2019.

- On May 29, 2014, URS submitted the *Plume Stability Tech Memo* to EPA, WVDEP, and Ergon. EPA comments on this report were included in the *Revised Groundwater Monitoring Work Plan* submitted to the EPA, WVDEP, and Ergon on April 22, 2015. EPA approval of the work plan was received on May 8, 2015. This Work Plan instituted the change from quarterly monitoring to annual monitoring. Annual groundwater monitoring has been completed since June 2015 and is ongoing. Results of the groundwater monitoring are submitted in annual groundwater monitoring reports to the EPA.

- To address the EPA's comments on the *Draft RFI Report* regarding Vapor Intrusion, the *Vapor Intrusion Analysis Scope of Work* Technical Memo was submitted to the EPA, WVDEP, and Ergon on April 14, 2014. On December 18, 2014, the Draft VI Work Plan was submitted to the EPA, WVDEP, and Ergon. EPA approval of the work plan was received on October 9, 2015.

- Field work for the soil gas and sub-slab sampling of the VI Work Plan was completed on November 9-18, 2015. On February 25, 2016, the *VI Data Summary Report* was submitted to the EPA, WVDEP, and Ergon. On October 31, 2016, the EPA issued final approval for the report.

- On August 17, 2017, the *Revised HHRA*, which included new VI data, was submitted to the EPA, WVDEP, and Ergon. Final EPA approval of the HHRA was received on March 27, 2018.

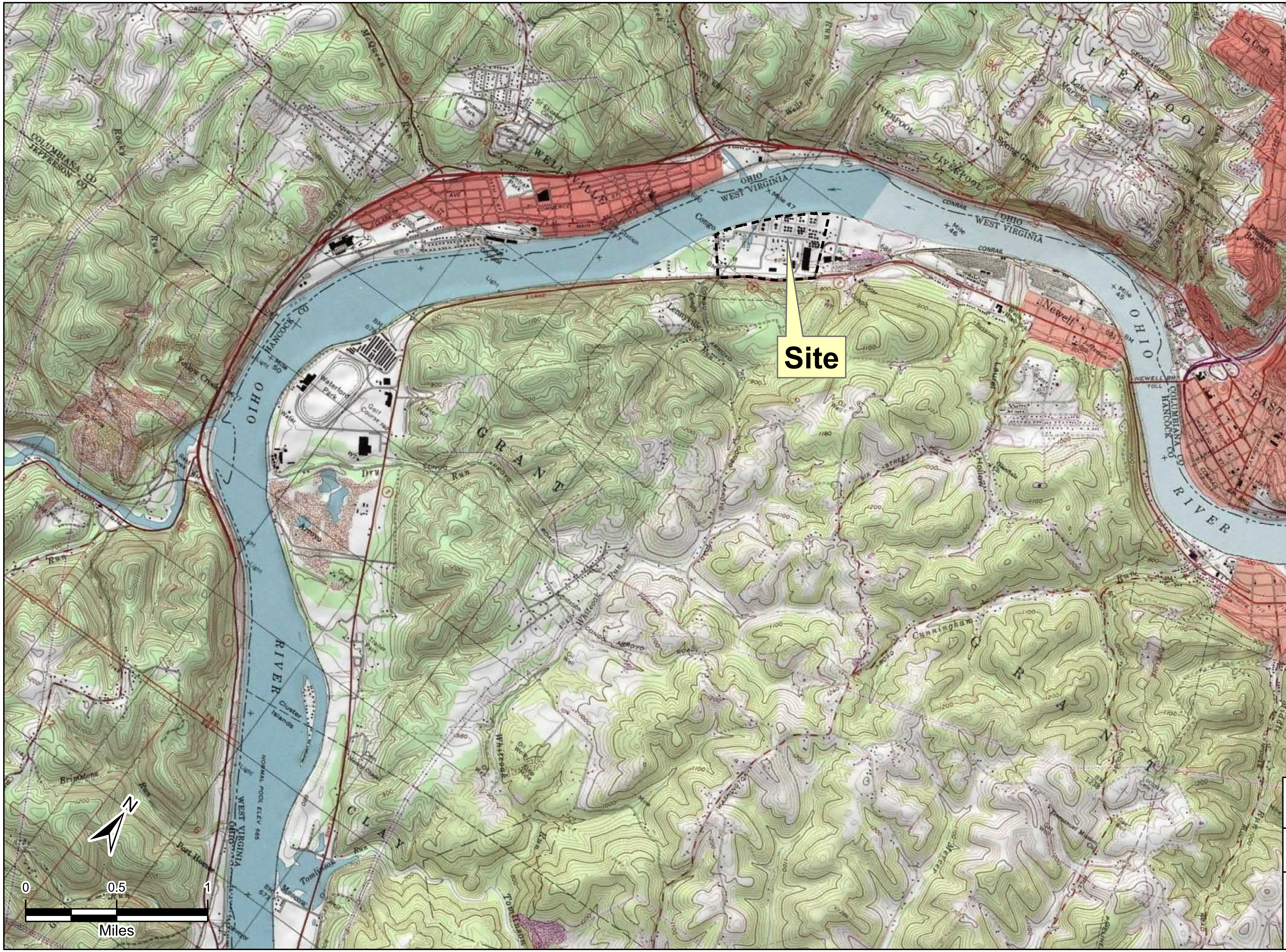

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Figure 1-1
Location and Topography
Former Quaker State/Ergon Refinery
Newell, West Virginia

Figure 1-2
Location of SWMUs and AOCs
Former Quaker State/Ergon Refinery
in Newell, WV

2 Site Geology and Hydrogeology, Affected Media, and Remedial Action Summary

2.1 Site Geology and Hydrogeology

2.1.1 Geology

The typical geology of the Ohio River Valley bottomlands consists of fine-textured alluvial unconsolidated deposits overlying coarser sand and gravel glacial outwash. Surficial deposits beneath the western area of the Refinery are composed predominantly of silt, sand, gravel, and occasional dry fill materials, extending to depths of 2 to 5 feet below ground surface (bgs). Underlying the fill deposits beneath this area and comprising the surficial deposits to the south is a layer of sandy to clayey silt and silty sand that extend to depths ranging between 7 and 25 feet bgs. These finer-textured deposits are underlain by a fine to medium sand that grades into coarser sand and gravel with depth. In the eastern area of the Refinery, the uppermost unconsolidated deposits are composed of silt, sand, gravel fill material, and reworked soils ranging between 2 and 8 feet thick. These deposits are underlain by coarse sand and gravel, with occasional cobbles that grade into predominantly sand and gravel.

The unconsolidated outwash deposits overlie bedrock that outcrops on the valley wall south of State Route 2 and extends under the Refinery to at least 70 feet bgs in the U-shaped Ohio River Valley. Borings drilled during the geotechnical investigation conducted prior to construction of the Refinery in 1970 reached bedrock at less than 35 feet bgs in the southeastern corner and at 68 feet bgs in the northeastern corner of the property. Bedrock was encountered in one boring (MW-26D) during the subsurface investigation at a depth of approximately 70 feet bgs. Geologic cross sections of the refinery are presented in **Appendix A**.

2.1.2 Groundwater

The depth to the groundwater surface is approximately 8 to 26 feet bgs at the facility. The shallower groundwater surface exists beneath the southern corner of the Refinery, and the deepest groundwater surface occurs in the northern corner of the site. The primary materials of the shallow alluvial groundwater system beneath the Refinery are coarse deposits of sand and gravel in the eastern portion of the site and fine to medium sand in the western portion of the site.

The shallow groundwater system in the alluvium beneath the site is recharged by infiltrating precipitation, discharges from the underlying bedrock, and river inflow. The river is dammed at the New Cumberland Lock and Dam, which is located approximately 5 miles downstream of the site and causes pooled water in the river to maintain a high enough level for commercial barge traffic; the river water level is commonly above the groundwater surface near the river at the site. The shallow system can also receive substantial recharge by inflow from the river under high river levels and with the use of the onsite water production wells.

The groundwater surface beneath the majority of the site is very flat, with an approximate average horizontal gradient of 0.0003 feet per foot during the 2018 groundwater monitoring event. In general, the groundwater gradient (groundwater flow direction) is westward from the central part of the site, with a northward gradient in the northern corner of the site where water production wells alter the nearby groundwater surface. The groundwater surface elevation contour maps for the site of June 4, 2018, June 5, 2017, May 31, 2016, and June 1, 2015 are included as **Figures 2-1 to 2-4**. The groundwater gauging data from November 2012 to June 2018 are presented in **Table B-1 of Appendix B**.

Based on river water level and groundwater elevation data of site wells, the horizontal hydraulic gradient is very commonly from the river and towards the site beneath the north-central part of the site (in the area of MW-21 to MW-24 and inland). Under this condition, the discharge of site groundwater from this area to the river is impeded or prevented. Occasionally, the gradient in this area can be towards the river (possibly during lower river water levels). In addition, at the northeastern and northwestern parts of the site near the active production wells, the groundwater gradients are toward the production wells (away from the river) during both high and low river level conditions.

Five onsite water production wells currently exist at the Refinery (NW-1 to NW-5) to produce water for non-potable, industrial uses. Well NW-1 is located in the western corner of the site, approximately 200 feet from the river. NW-2 is located between MW-3 and MW-4 in the northern corner of the facility (**Figure 2-1**). Wells NW-3 and NW-4 are within 300 feet of each other in the northern corner of the facility, approximately 100 feet from the Ohio River shoreline. Well NW-5 is located in the western corner of the Refinery, approximately 150 feet south of the Ohio River shoreline. The most commonly used wells for water production are NW-3, NW-4, and NW-5. A small localized depression in the groundwater table has been observed at the commonly used production wells as shown on **Figure 2-1**. When pumping, the horizontal cone of depression has an interpreted radius of approximately 100 to 150 feet around wells NW-3 and NW-4 in the northeast corner of the Refinery. In the northwestern corner of the Refinery, a cone of depression with a horizontal radius of approximately 150 feet is interpreted to exist around well NW-5, and a cone of depression with a horizontal radius of less than 100 feet is interpreted to exist around well NW-1, when operating.

2.2 Characterization of Site Constituents of Concern in Impacted Media

2.2.1 Soil

A summary of the COCs defined in soil samples collected during the RFI is provided in **Table 2-1**. A figure showing COC concentrations that exceed the Industrial Risk Based Concentrations (RBCs) in soil is included in **Appendix C**. These data are presented in the 2009 Revised Draft RFI Report (URS, 2009c). A current and future industrial land use scenario is assumed.

Table 2-1: Summary of 2009 RFI Soil COC Results

Site Area	RFI COCs in Soil
Plant Boilers	Benzo(a)pyrene, iron, and manganese exceeded the Industrial RBCs.
Satellite Storage Area	Iron and manganese exceeded the Industrial RBCs.
Old Heat Exchanger Cleaning Pad	One detection of manganese (out of 34 soil samples) exceeded the Industrial RBC.
Tank Bottoms Disposal Area No. 4 and No. 6	Tank Bottoms Disposal Area No. 4: Iron and manganese exceeded the Industrial RBCs.
	Tank Bottoms Disposal Area No. 6: Iron and manganese exceeded the Industrial RBCs.
New Heat Exchanger Cleaning Pad and Drum Cleaning Area	Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, iron, and manganese exceeded the Industrial RBCs.
Old Drum Storage Area	Iron, manganese, and mercury exceeded the Industrial RBCs.
Wastewater Treatment Area	Three metals (chromium, iron, and manganese) and three PAHs (benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene) exceed the Industrial RBCs.
Oily Wastewater Sewer System	Isolated detections of benzo(a)anthracene, benzo(a)pyrene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, ethylbenzene, and lead, as well as frequent detections of iron and manganese, exceeded the Industrial RBCs.

Site Area	RFI COCs in Soil
Tank Areas	Tank Area Nos. 1, 2, 5, 7, and 7A: No detections exceeded the Industrial RBCs. Tank Area No. 3: Two PAHs (benzo(a)anthracene and benzo(a)pyrene) exceeded the Industrial RBCs in shallow soil only. Tank Area Nos. 4 and 6: Benzene, toluene, ethylbenzene, and total xylenes (BTEX) and naphthalene exceeded the Industrial RBCs. Tank Area No. 8 and Lube Blending Area: Only iron and manganese in deeper soil samples exceeded the Industrial RBCs.
Process Pipeways (and methyl ethyl ketone [MEK]Area)	Two PAHs exceeded the Industrial RBCs in the Process Pipeway samples. Toluene and manganese exceeded the Industrial RBCs at the MEK area.

BTEX and naphthalene were detected at concentrations above the Industrial RBCs in soil exclusively in Tank Area Nos. 4 and 6, except for one toluene detection greater than its Industrial RBC in the MEK area.

PAHs were detected in soil greater than the Industrial RBCs in the southwestern portion of the site in Tank Area 3, Oily Wastewater Sewer System, Process Pipeways, MEK area, Wastewater Treatment Area, New Heat Exchanger Cleaning Pad/Drum Cleaning Area, and Plant Boilers area.

Of note is that a few metals (arsenic, chromium, lead, iron, and manganese), were detected at concentrations greater than their Industrial RBCs in soil samples at different locations across the site. It is likely that many of the metals (especially arsenic, iron, and manganese) are commonly present in site soil at natural background conditions.

Arsenic was detected in every soil sample for which it was analyzed and exceeded the screening value. The presence of arsenic appears to reflect general site-wide soil conditions. It is ubiquitously present (in both shallow and deeper soil samples) and is not a metal that is used in the industrial processes at this facility. Based on arsenic’s facility-wide distribution and lack of an industrial source, this metal is not considered a site-related COC in site soil.

2.2.2 Groundwater

2.2.2.1 History of Groundwater Investigations

The Refinery has undergone several phases of groundwater investigations since the 1990s. These phases included the RFI (1994–2005) and involved installing monitoring wells to collect groundwater samples at the Refinery and recovery wells (also called scavenger [SCAV] wells) to remove SPL. Most groundwater data were collected quarterly during IM monitoring, which began before the RFI. IM monitoring continued during and after the RFI and underwent several changes in scope. In 2014, the quarterly monitoring was changed after approval by the EPA to an annual schedule. An annual monitoring event was conducted in May/June 2015, June 2016, June 2017, and June 2018 to acquire site-wide groundwater data.

2.2.2.2 Dissolved COCs in Groundwater

Groundwater sampling was conducted in multiple phases during the 2009 RFI because COCs detected during the initial sampling led to the installation of additional wells (such as in the MEK Dewaxing Area). The following COCs were identified in site-wide groundwater based on the 2009 RFI data: BTEX, methyl tertiary-butyl ether (MTBE), and MEK. Benzene concentrations in groundwater exceeding the EPA maximum contaminant level (MCL) of 5 micrograms per liter (µg/L) were detected in two areas in the northern half of the Refinery. MTBE was the next most prevalent COC, with exceedances of its EPA residential tap water regional screening level (RSL) in five wells located in two small, discrete areas (an area north of the MEK Dewaxing Area and an area between wells MW-30 and SCAV-21). Concentrations of dissolved COCs in site groundwater as presented in the 2009 RFI report are shown on figures in **Appendix C**.

The 2009 Draft Revised RFI Report also indicates that arsenic was the metal most commonly detected in groundwater above its MCL of 10 µg/L. Concentrations of dissolved arsenic were historically detected between 0.75 micrograms per liter (µg/L) (MW-22 in 2006) and 235 µg/L (MW-13 in 1998). Arsenic is a naturally occurring inorganic constituent in the site subsurface materials and groundwater; its presence at higher concentrations in certain areas of groundwater is likely a result of the reduced (anaerobic environment) groundwater conditions caused by the natural attenuation (NA) of petroleum hydrocarbon constituents. Dissolved arsenic is localized to the anoxic footprint induced by bacterial degradation of the hydrocarbons.

Table 2-2 below presents the results of the annual groundwater monitoring event conducted in June 2018 (AECOM, 2018). The concentrations of dissolved COCs in site groundwater in 2015, 2016, and 2017 are similar to the 2018 data. In addition, the groundwater analytical results of site groundwater wells sampled from November 2012 to June 2018 are presented in **Table B-2** of **Appendix B**.

Table 2-2: Summary of Analyte Detections in 2018 Groundwater Samples

Analyte	Number of Detections	Concentrations (µg/L)	Regulatory MCL/RSL (µg/L)	Number of MCL/RSL Exceedances and Well ID
Benzene	1 of 22	28.5	5 (MCL)	1: MW-31
Toluene	4 of 22	6.44 – 332,000	1,000 (MCL)	3: MW-38R, MW-42, and MW-43
Ethylbenzene	0 of 22	None	700 (MCL)	None
Total Xylenes	0 of 22	None	10,000 (MCL)	None
MEK	2 of 22	386 – 45,700	560 (RSL)	1: MW-38R
MTBE	0 of 22	None	14 (RSL)	None
Dissolved Arsenic	15 of 22	2.56 – 64.2	10 (MCL)	10: MW-4, MW-29, MW-31, MW-38R, MW-42, MW-43, SCAV-13, SCAV-16, SCAV-17, SCAV-20

Notes:

MEK = 2-Butanone; MTBE = methyl tertiary-butyl ether; µg/L = micrograms per Liter: MCL = maximum contaminant level; RSL = regional screening level representing a target hazard quotient of 0.1 – May 2019

2.2.2.3 Distribution of Dissolved COCs In Site-Wide Groundwater

This subsection discusses the distribution of dissolved COCs in site-wide groundwater based on more recent groundwater conditions observed in 2015 through 2018. The area and extent of the dissolved COCs are primarily based on the location of historical releases, the direction and slope of the groundwater gradient, and natural attenuation conditions of the subsurface at the site. As discussed in Section 2.1.2, the groundwater gradient beneath the majority of the site is very flat, which limits the movement of the dissolved COCs beneath the site and helps prevents off-site migration of the dissolved COCs. Importantly, property boundary monitoring wells were installed to monitor for COC migration along the southwestern and northeastern property line, and along the 2,400-foot edge of the Refinery close to the Ohio River to confirm that no COCs were discharging to the river or other off-site properties. The June 2018 distribution of dissolved benzene, toluene, MTBE, and MEK detected in the sampled wells are illustrated on **Figure 2-5**. Figures showing the distribution of dissolved COCs in site groundwater prior to 2018 are presented in the annual groundwater monitoring reports (AECOM, 2013-2017).

Results of the 2015 to 2018 annual groundwater monitoring event indicate that areas of detected dissolved phase constituents in site-wide groundwater are significantly smaller than the areas presented in the 2009 Draft Revised RFI Report. Additionally, review of the 2015-2018 groundwater data confirmed that VOC COCs in the groundwater were only detected in the central part of the refinery property and significantly within the property boundaries. With

2015 to 2018 data, VOC COCs were detected in groundwater samples at concentrations greater than their MCLs/RSLs in the following wells: MW-31 (benzene), MW-38R (toluene and MEK), MW-42 (toluene and MEK), MW-43 (toluene and MEK), and SCAV-18 (benzene), which are the wells nearest to suspected historic release locations. Wells downgradient of the suspected source wells that define the main COC plumes indicate limited extent of the dissolved COCs with COC exceedances are all located in the center part of the refinery site.

The area of benzene greater than its MCL of 5 µg/L is in the vicinity of wells MW-31 to SCAV-18 and then northwestward towards SCAV-20; it occupies a distance of approximately 500 feet in the center of the Refinery. The well closest to the property boundary with COC concentrations exceeding a screening level was SCAV-18, located approximately 730 feet from the river near the center of the Refinery property; well SCAV-20 that is approximately 280 feet northwest (downgradient) of SCAV-18 has contained non-detected to very low concentrations (less than its MCL) of benzene.

Toluene has been detected in recent groundwater samples from MW-38R, MW-42, MW-43, and SCAV-16 of the MEK Dewaxing Area. Well SCAV-16 is approximately 170 feet northwest of source area well MW-38R and its groundwater contains toluene concentrations less than its MCL. No toluene was recently detected in the groundwater north of the MEK Dewaxing Area; toluene was last detected in this area in the 2015 samples. The 2009 RFI data reported most toluene detections and all MCL exceedances in these two areas (the MEK Dewaxing area and north of the MEK Dewaxing Area). Based on the 2018 data, the areas with historic toluene concentrations have decreased in extent significantly since the RFI.

Dissolved MEK has been detected in groundwater samples of wells MW-38R, MW-42, and MW-43 of the MEK Dewaxing Area. Of the 2018 samples, the MEK concentration of only the well MW-38R and MW-42 samples exceeded its RSL. The presence of MEK is limited to these three wells in site groundwater, indicating very limited movement of MEK within the Refinery site.

Groundwater samples collected in 2016 to 2018 from the property boundary wells did not contained detectable COC concentrations (AECOM, 2016-2018), except for dissolved arsenic in SCAV-13. Groundwater samples collected in 2015 from the property boundary wells did not contain detectable COC concentrations, except very low BTEX and MTBE concentrations (approximately 1 microgram per liter- ug/L) in the groundwater samples of wells GM-3D, MW-29, and SCAV-13 and dissolved arsenic in SCAV-13. These data from the property boundary wells are evidence of no offsite migration of dissolved COCs along the northern boundary of the river (wells MW-3, MW-24, MW-26E, and MW-29), along the eastern upstream boundary (wells MW-39, MW-40, PZ-10, and PZ-15, and SCAV-13) and along the western (downstream) boundary (wells GM-3D and PZ-13).

In the area of the on-site production wells, groundwater known to contain dissolved COCs that exceed an MCL/RSL does not exist within 1,000 feet for VOCs and 600 feet for arsenic of the five production wells (NW-1 to NW-5). In 2018, the COCs were not detected in groundwater samples collected from several monitoring wells (MW-26E, MW-39, PZ-13, and GM-3D) in the vicinity of production wells NW-3, NW-4, and NW-5, indicating that groundwater quality at the production wells is not adversely affected. Additionally, the site production wells are separated vertically from the uppermost groundwater zone by more than 30 feet of alluvial sediments. Between 2011 and 2017, no COCs were detected in MW-39 and PZ-13 groundwater samples, and only trace concentrations of MTBE (less than its RSL) were detected in MW-26E and GM-3D samples. Based on the recent data and as stated in the annual groundwater monitoring reports (AECOM, 2015-2018), the extraction of groundwater is not causing migration of the COCs in site groundwater.

Concentrations of dissolved arsenic in site groundwater based on the 2018 data are shown on **Figure 2-6**. The 2018 arsenic concentrations were very similar to 2015 to 2017 data. Arsenic is a naturally occurring constituent in the site soil and groundwater and, based on the types of industrial activities at the Refinery, its presence in site groundwater is not interpreted to be related to site operations. Concentrations of dissolved arsenic were detected in groundwater samples from wells throughout the Refinery between 2.79 and 64.2 µg/L. Arsenic concentrations above its MCL of 10 µg/L (red-colored values on **Figure 2-6**) were reported in the groundwater samples of wells MW-4, MW-29, MW-31, MW-38R, MW-42, MW-43, SCAV-13, SCAV-16, SCAV-17, and SCAV-20.

The highest detected dissolved arsenic concentrations were in the groundwater samples from wells MW-31, MW-38R, and MW-43, ranging from 44.1 µg/L (MW-38R) to 64.2 µg/L (MW-31). The detections of higher arsenic concentrations were generally in areas that also had BTEX detections, as documented in the 2009 Revised Draft RFI Report. Additionally, the higher arsenic concentrations were detected with low to negative redox measurements, indicating that arsenic is likely mobilized from the subsurface formation in reaction to reducing groundwater conditions where active biodegradation is occurring.

Based on the substantial amount of groundwater analytical data collected during the RFI and the continued data collected from monitoring wells installed near the property boundary, and the local dominant subsurface groundwater flow patterns beneath the site, there is no current evidence that dissolved COCs in site groundwater are migrating offsite or being discharged into the adjacent river. To provide further support that COCs are not migrating offsite, a groundwater fate and transport analysis of dissolved COCs is included in **Section 2.3**

2.2.2.4 Dissolved Phase Concentration Trends

This subsection discusses general groundwater COC concentration trends from RFI data (collected from 1994 through 2007) through 2018, with a more detailed discussion of concentrations trends from 2012 through 2018.

Wells with benzene concentrations greater than the MCL decreased from 21 wells depicted in the 1994 to 2007 data to one well of the 2018 data, as shown in **Table 2-2**. (Note that a few wells having groundwater with benzene in RFI data were not sampled in 2018.) Similarly, MTBE concentrations that exceeded the RSL decreased from five wells in the RFI data to no wells in 2018. Concentrations of toluene greater than its screening level occurred in groundwater samples from four wells for both the RFI data and 2018 sampling event.

The lower number of benzene and other COC detections in site wells in recent years (2015-2018) have significantly reduced the extent of COCs greater than their screening levels as compared to the RFI data. The nature and extent of benzene concentrations that existed in site wells along the northeastern boundary and central part of the site with the RFI data were not detected in the 2018 data. Overall, COC concentrations in groundwater have decreased or are no longer present in certain areas identified in the RFI data.

Arsenic was added to the annual groundwater monitoring program in June 2015. Groundwater analytical data for the last four years (June 2015 to June 2018) shows that arsenic concentrations are stable and within the same order of magnitude during this time. Dissolved arsenic concentrations are expected to decline as petroleum hydrocarbons are attenuated and the groundwater is restored to aerobic conditions (Brown et. al, 2010).

Concentration trend graphs plotting all available concentration data of dissolved BTEX, MTBE, and MEK over time in wells that had reported detections at any time from November 2013 through June 2018 sampling events (wells GM-3D, MW-4, MW-26E, MW-31, MW-38R, MW-42, MW-43, PZ-4, PZ-10, SCAV-13, SCAV-16 and SCAV-20) are provided in **Appendix D**. Wells that were sampled a few times were not graphed due to insufficient data (including wells MW-29, SCAV-5, and SCAV-17) because graphs with few data points show significant change over time. Only the graphs for the MEK Dewaxing Area wells include MEK concentrations. Data from the November 2013 monitoring event were chosen to be included in the concentration trend graphs because that data set contained a much larger number of sampled site wells compared to other sampling events within the last few years.

Mann-Kendall trend graphs are provided in **Appendix D** for wells that exhibited a COC with an MCL or RSL exceedance at any time from November 2013 through June 2018 (MW-31, MW-38R, and MW-42). Wells MW-7 and SCAV-18 did not have the 10 data points necessary to perform the Mann-Kendall trend analysis. Also, the Mann-Kendall trend analysis was not included for MW-43 because the wide variation of chemical concentrations detected in this well made it unsuitable for this analysis. The trend analysis was completed using ProUCL 5.1 using 95% confidence. A summary of the Mann-Kendall trend results is included below in **Table 2-3**.

The analyzed COCs with non-detect concentrations are included in the general concentration over time graphs and in the Mann-Kendall Trend graphs. The 2013 Interstate Technology and Regulatory Council (ITRC) Groundwater Statistics and Monitoring Compliance Guidance Document (ITRC, 2013) recommends that non-detect COCs should be included along with detected values when data are presented in graphs. For COCs reported below their laboratory reporting limits, the reporting limits are used for the non-detected concentration values. Simple substitution using the reporting limit to represent a non-detect concentration is the most conservative method to present non-detected chemical data. The reporting limits of the COCs are included on the graphs because they are not present above their reporting limits and may exist at concentrations below the reporting limits. The Mann-Kendall trend analysis evaluates detect and non-detect data in the same manner.

Table 2-3: Summary of Mann-Kendall Trend Analysis for MW-31, MW-38R, and MW-42

Well ID	COC	Mann-Kendall Trend Results	Number of Data Points	Approximate p-value
MW-31	Benzene	Statistically significant evidence of a decreasing trend at the specified level of significance.	32	7.4084E-8
MW-31	MTBE	Statistically significant evidence of a decreasing trend at the specified level of significance.	32	9.9548E-7
MW-38R	MEK	Statistically significant evidence of a decreasing trend at the specified level of significance.	16	1.1373E-6
MW-38R	Toluene	Statistically significant evidence of an increasing trend at the specified level of significance.	16	0.0325
MW-42	MEK	Insufficient evidence to identify a significant trend at the specified level of significance.	32	0.303
MW-42	Toluene	Statistically significant evidence of an increasing trend at the specified level of significance.	32	0.0326

Based on the visual review of historical and recent 2018 data and Mann-Kendall trend analysis results, dissolved-phase concentrations for COCs are declining over time in site groundwater in all sampled wells, except possibly for toluene in well MW-38R and MW-42 in the possible MEK release area first identified in 2005. As an example, benzene concentrations in the groundwater at MW-31, immediately north of the MEK Dewaxing Area, have declined over time. For well MW-31, the Mann-Kendall trend graphs of benzene and MTBE indicate declining concentration trends.

MW-31	June 2008	November 2012	June 2017	June 2018
Benzene	381 µg/L	88 µg/L	49.7 µg/L	28.5 µg/L

A decline of benzene concentrations is also derived for PZ-10 groundwater near site's northern boundary.

PZ-10	June 1998	June 2004	June 2010	June 2018
Benzene	220 µg/L	56 µg/L	11.4 µg/L	ND

In groundwater samples from SCAV-20 at central portion of the site, benzene concentrations have also decreased.

SCAV-20	June 2006	December 2010	June 2018
Benzene	66 µg/L	14.8 µg/L	ND

Regarding MEK in site groundwater, the wells sampled in 2018 have lower MEK concentrations when compared to June 2008 data (elevated MEK concentrations in June 2008). The exception is well MW-42, which had a MEK concentration of 386 µg/L in its 2018 groundwater sample. The Mann-Kendall graphs of MEK in MW-38R and MW-42 show a decreasing and increasing concentration trend, respectively.

Concentrations of MEK are provided for wells MW-38R and MW-42.

MW-38R	May 2014	June 2016	June 2017	June 2018
MEK	599,000 µg/L	57,200 µg/L	110,000 µg/L	45,700 µg/L

MW-42	June 2015	June 2016	June 2017	June 2018
MEK	ND	ND	3,200 µg/L	386 µg/L

Toluene concentrations in three wells associated with the MEK Dewaxing Area (wells MW-38R, MW-42, and MW-43) show stable or downward concentration trends based on data since 2010/2011. The Mann-Kendall graphs of toluene in MW-38R and MW-42 both show an increasing concentration trend. These results are likely being strongly influenced by the high concentrations from the possible MEK Area release first identified in 2005.

For MW-38R, concentrations have maintained a similar magnitude since the well was installed in 2008.

MW-38R	March 2008	June 2016	June 2017	June 2018
Toluene	252,000 µg/L	428,000 µg/L	262,000 µg/L	332,000 µg/L

For MW-42, toluene concentrations have decreased substantially since 2012.

MW-42	Feb 2012	June 2016	June 2017	June 2018
Toluene	64,400 µg/L	ND	1,340 µg/L	1,520 µg/L

For MW-43, toluene concentrations have maintained a similar magnitude since 2012.

MW-43	Nov 2012	June 2016	June 2017	June 2018
Toluene	91,200 µg/L	4,150 µg/L	5,280 µg/L	13,700 µg/L

2.2.2.5 Natural Attenuation in Groundwater

Lines of evidence to assess the NA of dissolved-phase COCs include the declining and stable COC concentration trends and the NA parameters that are indicative of biological degradation of COCs. The dissolved–phase COCs in the sampled site wells show stable or decreasing concentration trends as discussed in **Section 2.2.2.3**. In addition, the area of groundwater containing dissolved–phase COCs is smaller than that presented in the 2009 Draft Revised RFI Report, indicating minimal migration of the COCs and stable groundwater conditions. In particular, the limited extent of benzene, toluene, and MEK beyond their known or suspected previous source areas are evidence that active NA processes are degrading the dissolved COCs.

In addition to the observed declines of concentrations of COCs over time in site groundwater, certain groundwater conditions also provide evidence that NA is occurring, or that conditions are favorable for NA of the dissolved COCs. The following NA parameters have been collected during the annual monitoring event since 2015 to better assess the NA process in site groundwater:

- pH
- Redox
- Dissolved oxygen (DO)
- Iron, total
- Iron, dissolved (ferrous)

- Sulfate
- Nitrate/nitrite as total nitrogen
- Alkalinity

The DO, redox, and pH, as well as temperature and specific conductivity measured in the collected groundwater samples during the 2015 to 2018 monitoring events, are presented in **Table B-3 of Appendix B**. Low DO indicates that oxygen is being consumed via aerobic biodegradation of hydrocarbon constituents. These conditions are reflected when DO concentrations are typically less than 1 milligram per liter (mg/L) and redox has negative values.

Iron, sulfate, nitrate, and alkalinity values measured in groundwater samples are presented in **Table B-4 of Appendix B**. Under anaerobic conditions (i.e., after DO is sufficiently depleted), nitrate, sulfate, and ferric iron (Fe^{3+}) serve as terminal electron acceptors. Iron is reduced from ferric iron (Fe^{3+}), which is generally insoluble and stable under naturally oxygenated groundwater conditions, to ferrous iron (Fe^{2+}), which is more soluble in reduced groundwater conditions. Low concentrations of nitrate, sulfate, and ferric iron (Fe^{3+}), and high levels of ferrous iron (Fe^{2+}), indicate that biodegradation is occurring. Alkalinity in the groundwater is primarily due to the presence of carbon dioxide that is produced by the metabolism of microorganisms. Higher concentrations of carbon dioxide increase the alkalinity in the groundwater and are indicative of biodegradation.

A figure showing NA parameters of June 2018 in site groundwater is included as **Figure 2-7**. Graphs of the NA parameters measured in the 2015, 2016, 2017, and 2018 groundwater samples of unimpacted wells (i.e. wells without COC detections) and impacted wells (i.e. wells with COC exceedances of regulatory MCLs/RSLs) are presented in **Appendix E**. The unimpacted wells are wells GM-3D, MW-3, MW-24, MW-26E, MW-39, PZ-13, and PZ-15. The impacted wells are MW-29, MW-31, MW-38R, MW-42, MW-43, SCAV-5, SCAV-13, SCAV-16, and SCAV-20.

Groundwater samples collected from wells outside of the areas of COCs reflect background conditions. As shown in the NA graphs in **Appendix E**, unimpacted groundwater, in general, exhibits higher DO, redox, sulfate, and nitrate concentrations, and lower alkalinity values compared to impacted groundwater. As an example, the groundwater of MW-24, which is located on the northern boundary of the site, has not had any COC detections since it's installation in 2006. The groundwater samples of this unimpacted well from 2015 to 2018 had a field-measured DO concentration between 4.76 and 6.82 mg/L, positive redox value (69.2 to 232.50 millivolts [mV]), no detectable concentrations of total or soluble (ferrous) iron, sulfate concentrations of 66.6 to 101 mg/L, nitrate concentrations of 1.8 to 5.68 mg/L, and lower alkalinity (36.8 to 67.7 mg/L). Similar values for these parameters were measured in other unimpacted wells. In general, NA parameters between impacted and unimpacted wells have remained consistent between 2015 and 2018.

Wells that contain dissolved-phase COCs generally exhibit lower DO, negative redox, higher concentrations of total and soluble iron, lower sulfate and nitrate, and higher alkalinity values.

These conditions are positive indications of biological activity in the groundwater. For example, in the MEK Dewaxing Area, wells MW-31, MW-38R, MW-42, and MW-43 exhibit DO concentrations less than 2.5 mg/L and negative redox values. Total and soluble iron concentrations were much higher in groundwater samples from these wells than in unimpacted wells. Total iron ranged between 40 and 150 mg/L, and soluble iron ranged from 30 to 150 mg/L. These iron concentrations were likely caused by the reducing conditions in the impacted groundwater. Sulfate concentrations were less than 17.5 mg/L, and nitrate was not detected in the wells, indicating that these substances are being used in the biodegradation process. The alkalinity values ranged between 64.1 and 494 mg/L and were usually higher than concentrations in groundwater samples of unimpacted wells. Similar concentrations of the NA parameters were also measured in other wells with dissolved COCs.

In the central part of the site, dissolved benzene concentrations greater than its screening level have been detected in the groundwater of wells MW-31 and SCAV-18. These two wells have nearby wells with no benzene detections (MW-13R and SCAV-20). A review of the NA parameters of these four wells (MW-31, SCAV-18, MW-13R and SCAV-20) indicate DO concentration of less than 1.7 mg/L and negative redox values. A large range of total iron concentrations existed in the groundwater samples of the four wells. Well MW-31 had the highest iron concentrations from 60 to 135 mg/L, and well MW-13R had the lowest values from 1 to 15 mg/L. The respective sulfate concentrations in the groundwater samples of the four wells ranged from non-detect (ND) to 162 mg/L. Sulfate concentrations were highest in MW-13R (19.9 to 162 mg/L) and lowest in SCAV-20, where it was not detected. Nitrates were ND for groundwater samples of all four wells from 2015 to 2018. The values of the above NA parameters are indications that biodegradation and NA of the COCs are occurring in the groundwater of the four assessed wells as the electron acceptors are being utilized for the process.

In the LBA, NA parameters were analyzed in 2015 to 2018 groundwater samples acquired from two wells: MW-4 and SCAV-5. Graphs on the NA parameters from 2015 to 2018 are presented in **Appendix E**. These two samples exhibited DO concentrations less than 1.75 mg/L and negative redox values. Total and soluble iron ranged from 17 to 45 mg/L in the wells, indicating reducing conditions in the groundwater of these wells. Sulfate concentrations in MW-4 and SCAV-5 have decreased from 2015. These sulfate results indicate that sulfate is being increasingly used in the biodegradation process. Nitrate was not detected in the wells. The alkalinity values in the two wells were in the higher range, between 126 to 356 mg/L. Based on the lack of nitrates, presence of iron, and low redox, biodegradation of the dissolved COCs is likely occurring in the LBA. Additional electron acceptors of DO and sulfate are present to support further biodegradation of possible dissolved COCs in the groundwater of the LBA. In summary, the measured NA parameters in 2015 to 2018 groundwater samples containing COCs provide positive indications and are lines of evidence that biodegradation and NA of the COCs are occurring.

Review of NA data groundwater samples collected from 2015 to 2018 showed that unimpacted groundwater, in general, exhibits higher DO, redox, sulfate, and nitrate concentrations, and lower alkalinity values compared to impacted groundwater. Wells that contain dissolved-phase COCs generally exhibit lower DO, negative redox, higher concentrations of total and soluble iron, lower sulfate and nitrate, and higher alkalinity values. These conditions are positive indications of biological activity in the groundwater. These lines of evidence indicate that biodegradation and NA of the COCs are occurring at the site.

2.2.3 SPL

The ITRC published a technical document that established descriptors for light nonaqueous phase liquid (LNAPL) (i.e., SPL) including “residual” SPL, “mobile” SPL, and “migrating” SPL (ITRC, 2018). These descriptors relay the potential for SPL movement within the subsurface. The terms are defined as follows:

- **Residual SPL** describes the condition where SPL-filled pores are discontinuous; thus, SPL is immobile and functionally trapped in pore spaces. Residual SPL will not accumulate in a monitoring well because of its inability to flow (i.e., the SPL is at residual saturation).
- **Mobile SPL** describes the condition where SPL is present above residual saturation. Mobile SPL is capable of moving laterally and vertically within the existing SPL plume footprint. Mobile SPL will accumulate in a monitoring well.
- **Migrating SPL** describes the condition where SPL is able to move outside of the existing SPL plume footprint into a previously un-impacted area, thereby causing expansion of the footprint. This condition is only possible when there is sufficient SPL head pressure present at the fringe of the SPL plume to displace other pore fluids (air and groundwater) from the soil pores. Migrating SPL is mobile SPL, but not all mobile SPL is migrating SPL.

All SPL bodies eventually reach a stable or shrinking condition after a release and/or releases have been abated. The time to reach a stable configuration is dependent on a number of parameters, including SPL release history, subsurface matrix characteristics, and SPL physical properties, as well as the rate at which SPL is depleted through Natural Source Zone Depletion (NSZD) processes and/or engineered recovery systems. Numerous advances in the understanding of SPL behavior in the subsurface have occurred in the past few decades. Based on recent information, SPL stability is typically evaluated using multiple, complimentary lines of evidence, where agreement between multiple methods builds confidence in the conclusion.

2.2.3.1 SPL Composition and Sources

Based on the existing site data, three main areas of SPL exist at the Refinery and are listed below along with the general SPL chemical composition.

1. MEK Dewaxing Area (wells MW-5, MW-38R, SCAV-31, and MW-45) – MEK and toluene
2. North of the MEK Dewaxing Area (wells MW-32, SCAV-19, and SCAV-30) – lubricating oil and gasoline
3. LBA (wells MW-37, MW-41, SCAV-29, TW-06, and TW-07) – lubricating oil

In 2002 and 2006, samples of SPL were collected from MW-38, PZ-17R, PZ-18, TW-02, and TW-06. Most SPL samples were characterized as fuel oil or diesel range organics. The sample from well MW-38 south of the MEK Dewaxing Area contained both MEK and fuel oil. The MEK data for this well were obtained from groundwater monitoring and not the analysis of SPL.

In April 2009, samples of SPL were collected from wells MW-37 and MW-41 located in the LBA and submitted for chromatography analysis. The results are consistent with a mineral-based lubricating oil having higher concentrations of carbon number C_{15} to C_{50} chain lengths.

An additional SPL sample was collected from MW-41 on February 22, 2013 and provided specific gravity, density, and viscosity at three temperatures (70°, 100°, and 130° Fahrenheit). Values ranged from 0.877 to 0.8659 grams per centimeter for specific gravity, 0.8752 to 0.8537 grams per cubic centimeter for density, and 265 to 49.3 centistokes (232 to 42.1 centipoise) for viscosity. These data indicate that with increased temperature, the SPL has a decreased viscosity.

The sources of the SPL are from historic operations at the Refinery at a few main locations. The SPL in several wells in the LBA was caused by a suspected historic lubricating oil release(s) prior to 2004. Minor fuel oil releases occurred in the vicinity of well SCAV-19 north of the MEK dewaxing area and in the small areas of the northern tank areas. In the LBA, the inspections of ASTs and an oil-water separator indicate no evidence of ongoing leakage. In addition, the findings of a 2017 inspection of the underground collection piping network in the LBA tank farm area indicate no observable conditions in the investigated piping network that would result in a loss of captured fluids to the subsurface. An evaluation of the oily water sewer (OWS) that extends beneath the central part of the Refinery (both Ergon and Shell Plant leased parcels) demonstrated integrity of the current OWS system and no clear evidence of leakage from it. No known or suspected sources of SPL to the environment currently exist at the Refinery.

2.2.3.2 SPL Footprint and Hydrogeological Conditions

The footprint of SPL in site wells at the Refinery has remained similar as demonstrated for at least the past 8 years, except in the MEK area. Figures of the SPL footprint in 2013 to 2018 are presented in **Appendix F** (due to the change to annual reporting in 2014, no SPL map was prepared for this year). The SPL footprint in the MEK area has decreased in size, and SPL is now only present in MW-45. Based on SPL occurrence over time, the SPL footprint is not expanding. In the last 8 years, SPL has been identified consistently in the following wells:

- Well MW-7 – SPL has been present in the well since March 2013 and is not found in nearby SCAV-5.
- Well MW-15 and SCAV-17 – SPL is usually present in MW-15 and occasionally present in SCAV-17.
- Well MW-14 – SPL is found intermittently in this well and does not extend to nearby SCAV-18.
- Well SCAV-22 – SPL is usually present in this well and does not extend to any surrounding wells.

- Well SCAV-1 and SCAV-2 (western API Separator)– SPL is consistently found in both wells and does not extend to any nearby wells.
- MEK Dewaxing Area (wells MW-5, MW-38R, SCAV-31, and MW-45) – SPL is now only present in MW-45. No other surrounding wells contain SPL.
- North of the MEK Dewaxing Area (wells MW-32, SCAV-19, and SCAV-30) – SPL is usually present in SCAV-19 and occasionally present in SCAV-30 and MW-32.
- LBA (wells MW-37, MW-41, SCAV-28, SCAV-29, TW-06, and TW-07) – SPL is usually present in these wells and the footprint has remained stable.
- Well PZ-17R and SCAV-28 – SPL is usually present in PZ-17R and occasionally present in SCAV-28. SPL does not extend to nearby wells.
- SPL appears intermittently in both MW-9 and SCAV-23, but does not extend beyond these wells.

In the last 8 years SPL has not appeared in any wells that have not contained SPL in the past, indicating that there are no new sources of SPL. Additionally, the footprint of SPL has not expanded to include any new wells.

Hydrographs are a useful tool to identify unconfined and confined SPL behavior. Hydrographs compiled for all wells with historical SPL accumulations since 2012 at the site are provided in **Appendix F**. Hydrographs show trends between groundwater potentiometric elevation and measured SPL thickness. SPL is potentially migrating when fluid level gauging indicates a clear trend of increasing thickness of SPL in monitoring wells through time that is not attributable to seasonal water-table fluctuations or recovery efforts. Another indicator of potential SPL migration is the advancement of SPL across a portion of the monitoring well network previously lacking measurable SPL, suggesting that the SPL zone is expanding in that area. In an unconfined system, an indirect relationship between groundwater potentiometric surface elevations and SPL thickness observations is observed (e.g., SPL thicknesses increase as groundwater elevations decrease). Conversely in a confined SPL system, a direct relationship between groundwater potentiometric surface elevations and SPL thickness observations is expected (e.g., SPL thicknesses decrease as groundwater elevations decrease).

Unconfined conditions are typically observed for all wells at the site. This is a result of the alluvial unconsolidated deposits and glacial outwash present at the site, whereas SPL thickness is expected to decrease with increasing groundwater surface elevations. This condition is observed at the site and is particularly evident for wells MW-5, MW-7, MW-9, MW-15, MW-31, MW-41, MW-45, and SCAV-22.

Periodic SPL recovery from 2008 to 2012 through use of total fluids recovery and absorbent socks from wells can result in non-equilibrium conditions for most fluid gauging events for several years following the end of SPL recovery efforts. Increased SPL thicknesses were observed at wells MW-15, MW-37, MW-41, SCAV-19, SCAV-22, SCAV-26, SCAV-28, SCAV-29, TW-07, and PZ-17R after SPL recovery actions ended on June 22, 2012. SPL thicknesses in these wells have remained constant or appear to be decreasing (i.e., SPL thickness is decreasing with decreasing potentiometric surface elevation) since the initial rebound in 2012 and 2013. Annual manual SPL recovery began in 2015.

Despite fluctuating groundwater surface elevations, most wells have had decreasing to stable SPL thicknesses during the last 5 years (2014 through 2018), and there are some wells (GM-3, MW-38R, SCAV-3, SCAV-4, SCAV-31) that no longer have SPL accumulations. SPL in the MEK Dewaxing Area has had the most substantial reduction of its thickness in recent years, as the SPL is now only measured in MW-45 and no longer exists in nearby wells. In the LBA, the thickness of SPL has remained similar since 2012 and appears to be generally stable, including in well MW-37. A measurable SPL thickness in SCAV-29, on the northwestern edge of the LBA SPL footprint, has been stable at about 0.5 foot since the shutdown in 2012. In MW-7 at the northern edge of the Shell parcel, the measured SPL thickness decreased from 0.43 foot in 2017 to 0.11 foot in 2018. The SPL thickness appears to have stabilized in MW-7, and no SPL has been present in neighboring well SCAV-5, indicating that SPL in MW-7 continues to be present in a small area. SPL appears in other previously identified isolated areas, yet these wells are not showing any noteworthy change of SPL thickness, except for MW-15. The measured SPL thickness in MW-15 changed from 1.33 feet in 2016 to 2.32 feet in 2017 to 2.38 feet in 2018; a similar thickness of SPL was observed in the 2003 timeframe. The change in SPL thickness of only 0.06 foot from 2017 to 2018 suggests that the SPL thickness may be stabilizing in this well. No SPL was measured in nearby SCAV-17.

As previously discussed, the SPL footprint at the Refinery has remained similar as demonstrated for at least the past 8 years, except in the MEK area. The SPL footprint in the MEK area has decreased in size, and SPL is now only present in MW-45. Based on SPL occurrence over time, the footprint is not expanding. Overall, data on the hydrographs indicate that SPL migration is not occurring at the site. Fluctuations of SPL thicknesses during several years following the end of SPL recovery efforts are the result of SPL returning to equilibrium conditions. Recent SPL fluctuations are the result of fluctuations in groundwater surface elevations under unconfined conditions.

2.2.3.3 SPL Baildown Testing

In 2013, a series of SPL baildown tests were conducted in four wells with SPL accumulations: MW-15, MW-41, SCAV-19, and SCAV-29. These tests were conducted to determine whether the SPL transmissivities of the wells were favorable for SPL recovery. The baildown test procedures, analysis methods, and results were presented in the Quarter 4 2013 Groundwater Monitoring Report (URS, 2014).

SPL transmissivity represents the volumetric rate of SPL flow through a unit width of porous media per unit time, under a unit hydraulic gradient. A direct mathematical relationship exists between SPL transmissivity and the rate of SPL flow into a well; therefore, it is an ideal parameter for assessing SPL recoverability. SPL transmissivity calculations inherently account for the combined effects of aquifer matrix permeability, SPL physical properties, and the relative proportion of pore space occupied by SPL within a specified vertical interval of saturated material (i.e. SPL saturation).

An SPL baildown test is initiated by quickly removing accumulated SPL from a well. SPL baildown tests can be used to quantitatively characterize SPL recoverability in the area surrounding the test locations. SPL recovery using hydraulic methods yields negligible SPL volume when the SPL transmissivity is less than 0.1 to 0.8 square foot per day (foot^2/day) (ITRC 2018). Baildown test data were analyzed using the American Petroleum Institute (API) SPL Transmissivity Workbook (API Workbook) (API, 2012). The following two methods were applied within the API workbook to analyze the SPL baildown test data under unconfined conditions:

- B&R: Bouwer and Rice (1976)/Bouwer (1989).
- C&J: Cooper and Jacob (1946)/Jacob and Lohman (1952).

Each solution involves different assumptions regarding the response of fluid levels within the well to the removal of SPL. The C&J method is better suited for tests involving more rapid SPL removal periods, or tests that do not exhibit steady state flow conditions because transient storage effects are incorporated. The B&R method was developed utilizing the assumption of steady, radial flow of SPL to the test well after test initiation, making it ideally suited for tests involving longer SPL purging times. Results from the SPL baildown tests are included in the table below.

Well	Date	Initial Thickness (feet)	Test Duration (days)	Percent Recovered	SPL Transmissivity (feet2/day)		
					B&R	C&J	Average
MW-15	5/22/2013	0.69	1.3	1%	Not Analyzed		
	2/19/2013	0.47	2.9	60%	0.2	0.02	0.1
	8/20/2013	0.91	2.8	19%	0.02	0.03	0.03
	11/12/2013	0.15	1.1	13%	Not Analyzed		
MW-41	2/20/2013	1.82	1.7	60%	0.2	0.2	0.2
	5/21/2013	1.03	2.29	76%	0.3	0.3	0.3
	8/20/2013	1.46	2.95	92%	**1.5**	**2.8**	**2.2**
	11/12/2013	1.55	3	90%	0.7	**2.0**	**1.3**
SCAV-19	2/20/2013	0.12	3.0	25%	Not Analyzed		
	8/21/2013	0.13	2.0	8%	Not Analyzed		
	5/22/2013	0.09	1.2	11%	Not Analyzed		
	11/12/2013	0.15	1.1	7%	Not Analyzed		
SCAV-29	2/20/2013	0.47	1.8	27%	0.004	0.03	0.02
	5/21/2013	0.43	2.2	32%	0.02	0.1	0.1
	8/20/2013	0.43	2.9	44%	0.4	--	0.4
	11/12/2013	0.61	2.9	26%	--	0.1	0.1

Results indicate that SPL is not readily recoverable via hydraulic means based on the SPL transmissivity results being typically lower than 0.8 foot^2/day. All tests at SCAV-19 and tests in May and November 2013 at MW-15 were unable to be analyzed quantitatively as SPL did not recover sufficiently. Further, SPL recovery in wells MW-15, SCAV-19, and SVAC-29 indicate very low recoverability, as SPL thicknesses increased to 23 percent over 2.1 days, on average.

Based on the SPL transmissivity results for the four tests completed at MW-41, SPL appears to be recoverable from MW-41 during periods of low groundwater elevation. Test results for August 2013 and November 2013 indicate SPL transmissivities greater than 0.8 foot^2/day; however, groundwater was at a historically low elevation in August 2013, exposing more of the well screen and allowing greater SPL drainage into the well during testing. As a result, active recovery at this well would not likely produce sufficient SPL due to the fluctuation of groundwater levels and the indication that SPL is not recoverable for half of the year.

2.2.3.4 LBA UVOST® Investigation

In July 2013, an Ultraviolet Optical Screening Tool® (UVOST®) investigation was performed in the LBA to estimate the relative vertical and lateral extent of SPL content in the shallow subsurface materials. Results of this investigation were presented in the October 2013 Lube Blend Area UVOST Investigation Report (URS, 2013). The UVOST® method uses a laser-induced fluorescence technique in which the degree of fluorescence is proportional to the SPL content to indicate presence or absence of SPL at locations and lesser or greater relative saturation in comparison of locations where SPL is present. UVOST® logging was completed at 10 locations. In addition, soil samples were collected from two direct-push soil borings to visually confirm SPL and for laboratory analyses of BTEX, TPH-GRO, and TPH-GRO to calibrate the UVOST® signal response and the physical soil characteristics of the subsurface intervals.

The UVOST logs revealed substantial variations in the UVOST signal responses within both the different borings and within each boring. Review of reference emitter response (%RE) values in the UVOST logs collected at the site resulted in value ranges between the baseline (within 5 percent of the RE) and 923%RE. Evaluation of the UVOST data and other soil information suggests %RE values greater than 270%RE are related to free-phase SPL; %RE values greater than 270%RE were recorded in 5 of the 10 borings. Based the UVOST® logs, the approximate high-content SPL zone of interest is less than 0.1 foot to 3 feet thick at a depth between 15.3 and 20.2 feet bgs.

As shown on **Figure 2-8**, the presence of SPL is most significant beneath the northern corner (UV-2) and the southern edge (UV-5) of the LBA. The maximum UVOST signal responses and greatest SPL interval thicknesses were identified at these two locations. The UVOST signals were negligible to minor beneath the southeastern portion of the LBA near borings UV-6, UV-7, and UV-9 and in the northwestern corner of the LBA near boring UV-1. These results placed southern and northwestern boundaries on the SPL footprint in this area.

2.2.3.5 Natural Source Zone Depletion

NSZD is a combination of natural processes that decrease the mass of SPL in the subsurface over time. The mechanisms responsible for SPL depletion include volatilization, dissolution, and biodegradation. The significance of these mechanisms is related to the SPL composition (e.g. the volatility, solubility, and biodegradability of SPL constituents) and the site setting. The site setting considerations are related to geochemistry, microbial ecology, and the subsurface characteristics that control movement of soil gas and groundwater into and out of the source zone. NSZD occurs when processes act to physically redistribute SPL components to the aqueous phase via dissolution or to the gaseous phase via volatilization. In turn, dissolved or volatilized SPL constituents can be biologically degraded by microbially mediated enzymatic activity. Biodegradation rates of SPL constituents dissolved in groundwater or volatilized in soil gas depend on the type and availability of electron acceptors (e.g., oxygen [O_2], nitrate [NO_3^{-2}], sulfate [SO_4^{-2}], ferrous iron [Fe^{3+}], and carbon dioxide [CO_2]) in the subsurface soil and groundwater.

Biodegradation of SPL constituents can occur through a number of microbially-facilitated reactions, depending on the availability of terminal electron acceptors (TEAs) such as oxygen, nitrate, manganese and iron oxides, and sulfate. Within SPL source zones, where hydrocarbon concentrations and electron acceptor demands are high, the above TEAs are depleted, and methanogenesis may become the dominant degradation pathway. During each of these biodegradation reactions, essentially all of the carbon present in SPL is converted to carbon dioxide and methane, which partition into the gas phase and migrate upward into the vadose zone.

Between November 9 and 18, 2015, interior sub-slab (SS) and exterior soil gas (SG) sampling points were sampled in three buildings and at 14 exterior locations, as shown on **Figure 2-9 and 2-10**. Atmospheric gases in site soils were measured in all 29 soil gas samples (not including duplicate samples) to assess their concentrations and investigate evidence of NSZD (**Table 2-4**). The full analytical results are presented in the Vapor Intrusion Data Summary Report (AECOM, 2016).

Table 2-4: Summary of Atmospheric Gas Concentrations in Exterior/Unbuilt and Interior Sub-Slab Soil Gas Sample Locations

Analyte	Number of Detections	Concentration Range (percent)
Oxygen	SG: 14 of 14 SS: 15 of 15	SG: 1.2 to 21 SS: 3 to 21
Nitrogen	SG: 14 of 14 SS: 15 of 15	SG: 67 to 92 SS: 80 to 83
Methane	SG: 10 of 14 SS: 1 of 15	SG: 0.02 to 30 SS: 12
Carbon dioxide	SG: 14 of 14 SS: 13 of 15	SG: 0.12 to 12 SS: 0.043 to 4.2

SG = Exterior/unbuilt Soil Gas Samples

SS = Interior Sub-slab Soil Gas Samples

Methane and carbon dioxide are often found in soil gas because they are generated by soil microbes as organic compounds/material in soil decomposes. In interior sub-slab samples, relatively low carbon dioxide values indicate that there is not substantial aerobic biodegradation taking place. “Excess” oxygen was present in almost every sample, indicating that the soils have the capacity to degrade more hydrocarbons should they be present. Oxygen concentrations exceeded 10 percent in each sample, except for the SS-15 sample with elevated methane and 3 percent oxygen reported.

Higher concentrations of methane and carbon dioxide were detected in the exterior/unbuilt soil gas samples. Methane was detected in 10 of the 14 samples, with a maximum of 30 percent (SG-14); however, oxygen levels were low in those same exterior soil gas samples. An inverse relationship between oxygen and methane concentrations exists as methane is readily oxidized in the presence of oxygen.

Atmospheric gas data indicate that NSZD is occurring. Areas under buildings where petroleum hydrocarbons (PH) concentrations are not evident have elevated oxygen and low methane concentrations. In interior sub-slab sample SS-15, low oxygen levels and elevated methane and carbon dioxide levels indicate that biodegradation is breaking down the PHs and other possible non-COC organic compounds.

2.2.3.6 Summary of SPL Conditions

Based on the existing site data, three main areas of SPL exist in the subsurface at the Refinery and are listed below.

- MEK Dewaxing Area (wells MW-5, MW-38R, SCAV-31, and MW-45)
- North of the MEK Dewaxing Area (wells MW-32, SCAV-19, and SCAV-30)
- LBA (wells MW-37, MW-41, SCAV-29, TW-06, and TW-07)

Other isolated occurrences of SPL have also been observed at the facility at SCAV-1, MW-7, MW-9, MW-15, MW-14, PZ-17R, and SCAV-22.

The sources of the SPL are from historic operations at the Refinery at a few main areas. Minor fuel oil releases occurred in the vicinity of well SCAV-19, north of the MEK dewaxing area and in the small areas of the northern tank areas. The SPL in several wells in the LBA was caused by a suspected historic lubricating oil releases from prior to 2004; albeit, there are no reported releases from the tanks and other structures in the LBA. Results of the 2017 LBA line inspection program indicate no observable conditions in the investigated piping network that would result in a loss of stored fluids to the subsurface. There are no known or suspected on-going SPL releases at the Refinery.

The SPL footprint at the Refinery is well-defined and has remained similar as demonstrated for at least the past 8 years. SPL data indicate the footprint is not expanding. The largest areas of SPL are located near the center of the site, a significant distance away from any offsite receptors, including the river. The main area of SPL in the LBA is approximately 315 feet from any property boundary. The closest SPL (PZ-17R) is to the property boundary is approximately 210 feet from the boundary.

Calculated SPL transmissivities are typically lower than 0.8 sq. foot/day in tested wells. These results indicate that SPL is basically immobile and not readily recoverable via hydraulic means.

SPL in the subsurface, that could be encountered by a receptor, is present at the largest amount directly above and below the water table. The shallowest groundwater depths in the SPL areas range from approximately 13 feet bgs (SCAV-19) to 24 feet bgs (PZ-17R). SPL is not anticipated to be encountered by current or future site workers. An environmental covenant preventing potable use of groundwater will prevent site workers from being exposed to SPL present in groundwater. Additionally, the depth of the SPL below ground surface is more than future anticipated excavation activities at the site (buried utilities, tank foundations, etc.).

Atmospheric gas data indicate that NSZD is occurring. In impacted areas, low oxygen levels and elevated methane and carbon dioxide levels indicate that biodegradation is breaking down the PHs and other possible non-COC organic compounds.

2.3 Groundwater Fate and Transport Analysis of Dissolved COCs

Fate and transport modeling of site groundwater using the BIOSCREEN (Newell, C.J., McCleod, R.K., and Gonzales, J., 1996) modeling was conducted to predict the nature and extent of two main dissolved COCs in site groundwater (benzene and toluene) in and downgradient of a source area over time and to assess the credibility of the biodegradation process of dissolved organic COCs in site groundwater. Information and detailed results of this analysis are provided in **Appendix G**.

The BIOSCREEN modeling study evaluates the NA processes and movement of two main dissolved COCs at the site: benzene and toluene. These two compounds have an area of dissolved concentrations with a known/suspected source area that allows fate and transport modeling. In addition, benzene and toluene exist at concentrations greater than their MCLs in certain areas of site groundwater. The objective of the modeling was to predict the extent and concentration of the benzene and toluene in site groundwater in a source area over time and the extent of their plumes, considering the combined effects of advection, dispersion, sorption, and biodegradation. The modeling study attempts to simulate natural processes affecting dissolved petroleum constituents in the subsurface environment while remaining reasonably conservative and not overestimating constituent mass reduction. Model simulations were conducted based on the general site groundwater conditions, the current dissolved benzene and toluene concentrations, the site-derived biodegradation rates, and the hydrogeological properties of the groundwater system at the site. The benzene and toluene biodegradation rates are approximately represented as first-order reactions. The modeling results show the benzene and toluene concentration distributions along the plume center line and the downgradient plume extents at various times. The objective of this modeling study was to demonstrate the presence of active biodegradation processes in site groundwater.

For this analysis, the chemical depletions of benzene and toluene source areas were approximated as a first-order decay process, and the half-lives of source depletions were estimated from the benzene and toluene concentration decays in groundwater of the source areas. Specifically, in the benzene source area of MW-31 and the toluene source area of MW-38R, the half-lives of source depletions were estimated as 3.06 and 4.14 years, respectively. Consequently, a source depletion half-life of 5.0 years was conservatively used for both benzene and toluene sources in site groundwater. The BIOSCREEN model was conducted under a first-order biodegradation scenario with a depleting source (assuming a half-life of 5 years), which represents site parameters. For this analysis, the source material was considered to be dissolved COCs (solute) and the presence of free-phase material (SPL) was not included in the model.

With the declining source scenario, the baseline simulation results show that dissolved benzene and toluene at concentrations exceeding their MCLs would approach “steady-state” in approximately 15 and 20 years, respectively. The “steady-state” plumes with benzene or toluene concentrations exceeding the MCLs of 5.0 µg/L and 1.0 mg/L, respectively, are predicted to extend only approximately 110 feet downgradient of their source area. The simulation results also show that the maximum benzene and toluene plume concentrations are predicted to decrease below their MCLs in approximately 35 years and 50 years after start of simulation, respectively. Thus, under existing site conditions, such small downgradient extents of the steady-state benzene and toluene plumes indicate that the plumes will not reach the downgradient property line. A buffer area of 800 to greater than 1000 feet would exist for the respective benzene and toluene plumes to continue to degrade prior to reaching the property line if they were to continue to move in that direction. Of note is the modeled benzene concentration of 0.60 mg/L represents well MW-31 groundwater in September 2006, and thus, the model simulation is at 12 years in 2018. Also, the degradation of the benzene to less than its MCL is an additional 23 years from 2018 with the presumed input parameters. The actual benzene concentration detected in well MW-31 in 2018 of 28.5 ug/L is less than the predicted benzene concentration of approximately 100 ug/L per the simulation. This favorable comparison provides credibility to the results of the benzene simulation.

A sensitivity analysis was conducted by altering the main parameter’s affected fate and transport of the dissolved COC, biodegradation rates, and groundwater velocity. Even when the biodegradation half-life value was doubled, and the groundwater velocity was doubled in the baseline simulation for both COCs, the downgradient extent of benzene and toluene concentrations above its MCLs only increased by 60 feet (less than 200 feet downgradient from source areas). Considering the property line is 900 feet or more downgradient from the potential source areas, a significant buffer area (over 600 feet long) exists for continued NA to degrade both constituents.

The model simulations demonstrate that dissolved benzene and toluene plumes from the identified source areas would not extend downgradient to the property boundary, even under the worst-case scenario. A comparison of the different simulations with actual site data indicates that active biodegradation is occurring in site groundwater to reduce the COC concentrations. For both benzene and toluene, current site data indicates that the plumes only exist in a small area near or at a relatively short distance downgradient of their source areas within the refinery boundaries.

Results of this fate and transport analysis indicate the biodegradation process is and will continue to reduce the COC distribution and concentrations in site groundwater. This condition and finding support the potential use of a Monitored Natural Attenuation (MNA) or a no action alternative at the site for dissolved petroleum COCs in certain areas. The presence of possible solubilizing SPL sources would have some influence on the final success of the NA process in site groundwater.

2.4 Results of Risk Assessment

As part of the RFI process, an RA was completed to address exposure by current and future receptors to groundwater, soil, and indoor air. The RA was completed most recently in August 2017 by RBR Consulting Inc., under agreement with AECOM. The 2009 Draft Human Health and Ecological Risk Assessment Report was submitted in June 2009. The ecological portion of the RA was approved by the EPA on February 25, 2015. To address EPA comments on the human health portion of the HHRA, the 2016 Revised Human Health and Ecological Risk Assessment Report was submitted in August 2016. A revised version was submitted August 17, 2017, and final EPA approval was received on March 27, 2018.

The approved RA indicated that there is negligible potential for adverse effects to current worker receptors exposed to soil or groundwater from the eight exposure areas or to indoor air of existing buildings at the Refinery. For a future indoor worker potentially exposed to constituents in indoor air of buildings hypothetically present at the exterior soil gas sampling locations, there is also negligible potential for adverse effects. Only the theoretical potable use of groundwater by hypothetical future adult and child residents yielded unacceptable potential risk. Additionally, the RA concluded that dissolved COCs are not migrating offsite in site groundwater.

Importantly, the unacceptable potential risk to hypothetical future adult and child residents for the potable use of site groundwater will be addressed via land use limitations and activity restrictions per a land use/environmental covenant placed on the subject property and recorded with the local county. A draft environmental covenant was created with collaboration from the site operator, EWVI, and was submitted to the EPA for review on April 23, 2019. This covenant, which will be approved by EPA and WVDEP, will be finalized after EPA approval of this CMS and the Final Decision document. The environmental covenant will include the following two site activity and use limitations:

1. The property will be used for industrial (non-residential) purposes only.

2. No use of groundwater for potable purposes (including drinking water and routine personal showering/washing). Groundwater at the subject property can be used for industrial and other purposes.

The environmental covenant to be recorded for the site will specifically state that groundwater at the facility property shall not be used for any purpose other than industrial (non-residential) activities, unless it is (a) demonstrated to EPA that such use will not pose a threat to human health or the environment or adversely affect or interfere with the final remedy, and (b) EPA provides prior written approval for such use. The covenant also states that the use of groundwater for potable purposes (including drinking water and routine personal showering/washing) is prohibited, and that groundwater at the property can be used for industrial purposes only. This covenant will make the groundwater pathway incomplete for the hypothetical future adult and child residents.

2.5 Interim Remedial Actions

Interim remedial actions have been used to address SPL at the site. No remedial actions for groundwater or soil have been conducted at the refinery.

2.5.1 Total Fluid Pumps and Sorbent Socks for SPL Removal

SPL recovery via total fluid pumps and sorbent socks was completed from 1994 to 2012. In 1994, Shell began actively recovering SPL from releases that were documented prior to sale of the refinery. Work was conducted in accordance with the IMWP dated March 18, 1994. It was a goal of the IMWP (HMI, 1994b) to *"contain and recover floating hydrocarbon on the shallow ground water, thereby reducing the potential for the spread of hydrocarbon to areas not currently affected."* Scavenger wells were equipped with total fluid pumps that recovered water and SPL, which were discharged to the OWS. This material was then processed in the on-site waste water treatment plant (WWTP) prior to discharge under Ergon's NPDES permit. Thirty-one scavenger wells were installed and subsequently taken offline when no longer needed. By 2012, only two scavenger wells were in continuous operation. Recovery of SPL was achieved by placing sorbent socks into 12 monitoring wells and scavenger wells with limited SPL accumulations. A table of operation over time is presented in **Table 2-6**.

Over time, the extent of SPL and dissolved-phase concentrations declined in many areas or, at a minimum, remained stable. After a review of the historical SPL recovery data, it was determined that SPL recovery efforts were no longer having a substantial and beneficial effect on changing or improving the condition of the site. To further validate this conclusion, and with the approval of the EPA, SPL recovery was discontinued for a period of one year in July 2012. Total fluid pumps were turned off, and all sorbent socks were removed from the wells. SPL baildown testing determined SPL was not readily recoverable, as described in **Section 2.2.3.3**.

In 2013, SPL footprint and thicknesses during the one-year shutdown were compared to historical SPL data. Results of the shutdown were presented in the Quarter 4 2013 Groundwater Monitoring Report (URS, 2014). SPL thicknesses had decreased or, where thicknesses were fluctuating, lateral expansion of SPL footprint was not occurring. Results indicated that SPL recovery efforts were having minimal effects in changing or improving the condition of the site. After approval from the EPA, SPL recovery was discontinued indefinitely, and fluid gauging during the groundwater monitoring program continued to monitor the SPL footprint, which remained consistent with initial recovery cessation conditions. Recent SPL conditions at the site have not supported the reactivation of the existing total fluids recovery system.

2.5.2 EFR Testing for SPL Removal

From March through early May 2009, enhanced fluid recovery (EFR) by vacuum extraction and a dual packer system was used in two LBA wells (MW-37 and MW-41) to evaluate SPL recovery. In each well, packers were installed above and below the intake of the vacuum inlet to isolate a narrow interval of the formation. Vacuum was applied and adjusted until water/SPL lift was achieved. The vacuum extraction and dual packer system were adjusted for the duration of the fluid recovery event to maintain recovery at the water/SPL interface.

Neither of the wells responded favorably to the EFR. Only enough SPL was recovered to coat piping and tubing, and no measurable quantity was removed from the wells. The material that coated the piping appeared to be a high molecular weight, very low vapor pressure lubricating oil. Use of EFR was determined to be an ineffective method to recover SPL at the site.
A summary letter report on this activity was prepared by URS and provided to the EPA on June 10, 2009.

2.5.3 SPL Manual Recovery

Manual SPL removal by bailing began in May 2015 and continues to be completed during the annual groundwater monitoring event. Wells with SPL thickness greater than 0.1 foot are bailed to remove the SPL. Recovery was completed with a bailer until no measurable SPL remained in a well. **Table 2-5** presents the approximate amount of SPL bailed from the wells in 2015 to 2018. The volumes of SPL recovered from the site wells during the four annual monitoring events were 6.78 L (1.79 gallons), 10.69 L (2.83 gallons), 12.35 L (3.26 gallons), and 9.96 L (2.63 gallons), respectively. Volumes of recovered SPL are minimal and do not suggest potential for greater SPL recovery via hydraulic means. Manual SPL recovery is having a negligible affect to reduce the overall mass of the SPL in the subsurface.

Table 2-5: SPL Recovered During Bailing in 2015, 2016, 2017, and 2018

2015	
Well Name	**Estimated Recovery (L)**
MW-7	0.11
MW-15	1.5
MW-37	2.0
MW-41	1.05
MW-45	0.05
PZ-17R	0.25
TW-06	0.04
TW-07	0.05
SCAV-1	0.255
SCAV-22	0.125
SCAV-23	0.075
SCAV-26	0.750
SCAV-28	0.025
SCAV-29	0.5
Total	6.78 (1.79 gal)

2016	
Well Name	**Estimated Recovery (L)**
MW-7	0.41
MW-9	0.015
MW-15	1.03
MW-32	0.02
MW-37	4.1
MW-41	0.66
MW-45	0.19
PZ-17R	0.5
TW-06	0.04
TW-07	0.075
SCAV-1	0.1
SCAV-17	0.02
SCAV-19	0.16
SCAV-22	0.44
SCAV-23	0.02
SCAV-26	1.790
SCAV-28	0.025
SCAV-29	1.08
SCAV-30	0.02
Total	10.69 (2.83 gal)

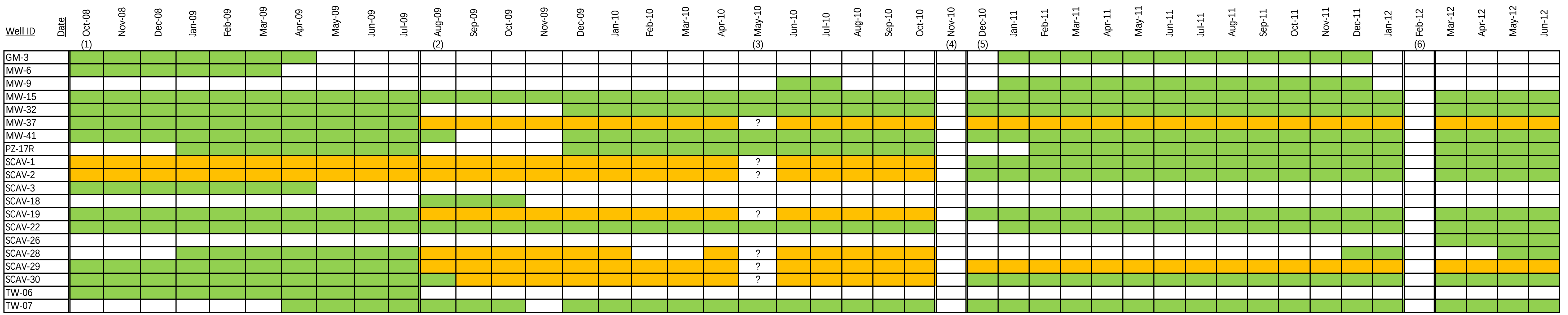
2017	
Well Name	**Estimated Recovery (L)**
MW-7	0.3
MW-14	0.05
MW-15	2.0
MW-37	5.0
MW-41	1.0
MW-45	0.1
PZ-17R	0.15
TW-06	0.02
TW-07	0.02
SCAV-1	0.025
SCAV-2	0.02
SCAV-19	0.05
SCAV-22	0.6
SCAV-29	3.0
SCAV-30	<0.01
Total	12.35 (3.26 gal)

2018	
Well Name	**Estimated Recovery (L)**
MW-7	0.075
MW-15	1.5
MW-37	4.25
MW-41	1.0
MW-45	0.2
PZ-17R	0.15
TW-06	0.02
TW-07	0.02
SCAV-1	0.025
SCAV-2	0.015
SCAV-19	0.05
SCAV-22	0.4
SCAV-26	0.75
SCAV-29	1.5
Total	9.96 (2.63 gal)

2.5.4 Summary of SPL Removal and Testing

Information acquired via several SPL recovery methods indicate only minimal SPL recovery can be achieved at the site and is believed to have a negligible affect to reduce the overall amount of the SPL in the subsurface. SPL recovery via total fluid pumps in site wells used from 1994 to 2012 had minimal effects in changing or improving the condition of the site. Thus, SPL recovery was discontinued in 2012. Recent site conditions did not support the reactivation of the existing total fluids recovery system. Based on the testing of two LBA wells with higher SPL accumulations, use of EFR was determined to be an ineffective method to recover SPL at the site. Results of manual bailing of site wells with measurable SPL for several years indicate minimal amounts of recovered SPL and do not suggest potential for greater SPL recovery via hydraulic means. Manual SPL recovery has had a negligible affect to reduce the overall mass of the SPL in the subsurface.

Table 2-6: Operating Chart: Interim Measures SPL Recovery, 2008 to June 2012 Shutdown



(1) September 2008--conducted static gauge-all product thickness study
(2) Recommendation to EPA based on product thinkness study enacted
(3) Refinery shut down; no access ? - no information on pumping activity
(4) November 2010--conducted static gauge-all product thickness study
(5) Recommendations to EPA based on product thickness study enacted
(6) February 2012--conducted static gauge-all product thickness study
(7) June 2012 - suspended recovery efforts, conducted baildown tests to assess SPL mobility

Absorbent Sock | Total Fluid Recovery Pump | Periodic gauging of water and product levels only

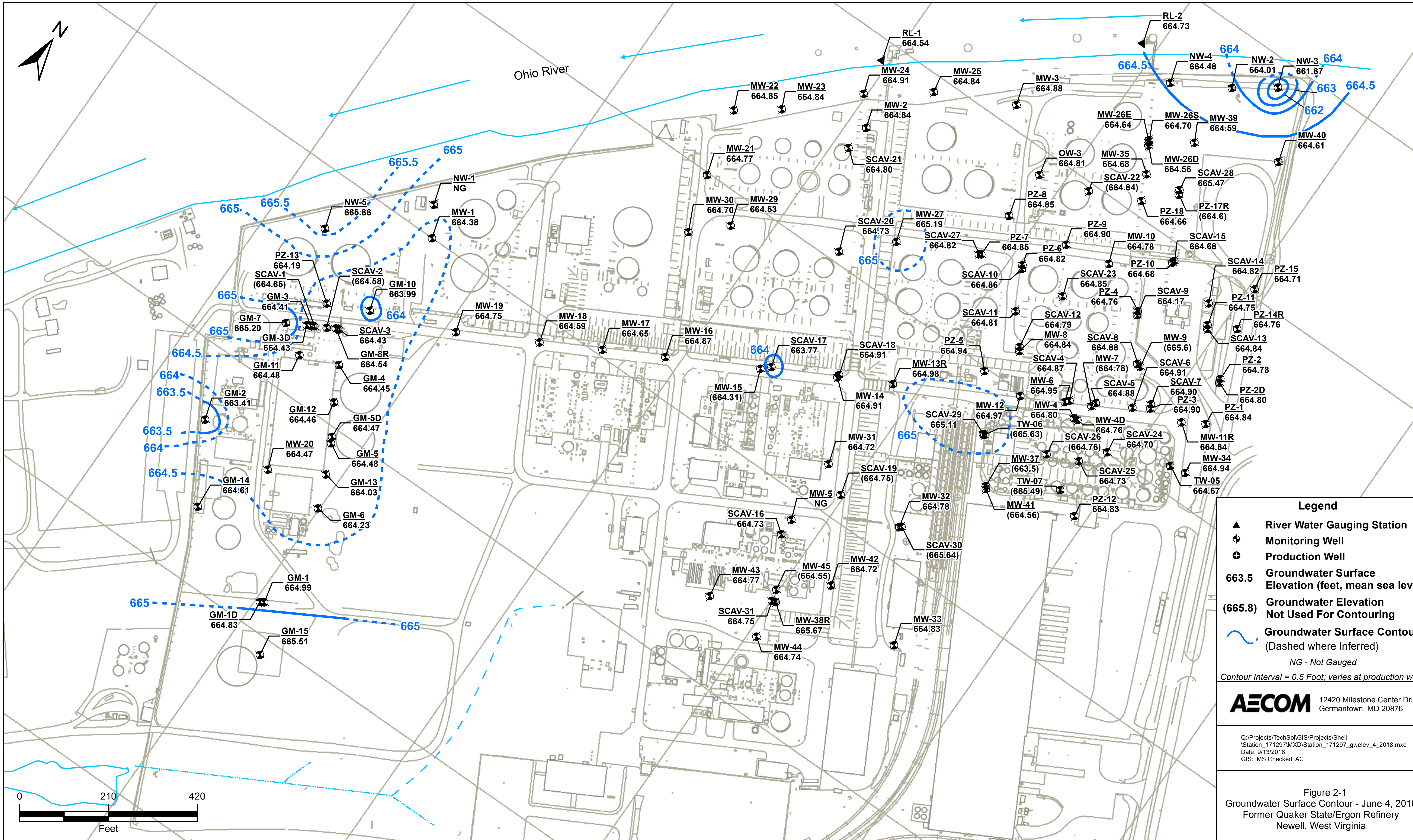
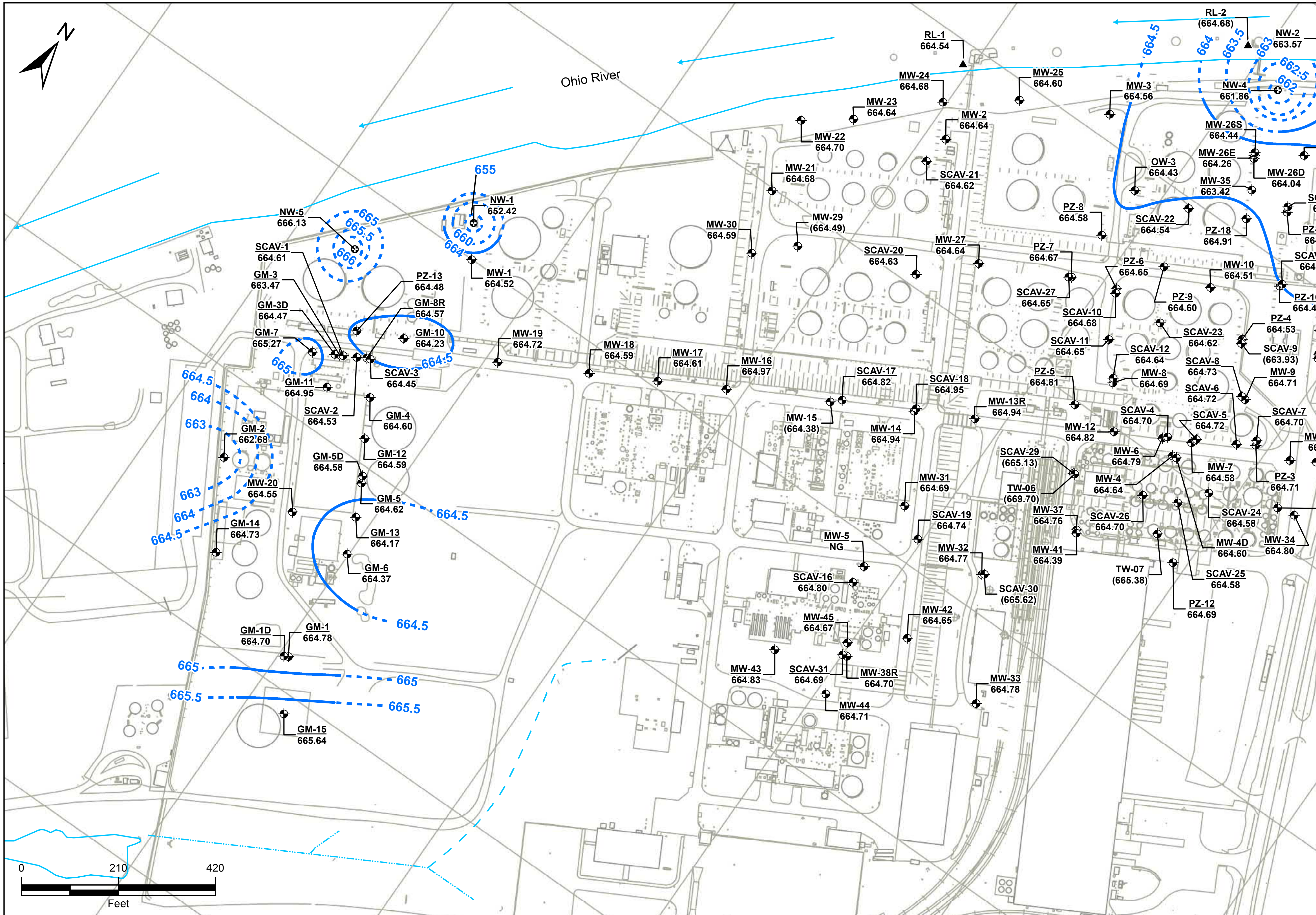


Figure 2-1
Groundwater Surface Contour - June 4, 2018
Former Quaker State/Ergon Refinery
Newell, West Virginia



Legend

- ▲ River Water Gauging Station
- Monitoring Well
- Production Well
- 663.5 Groundwater Surface Elevation (feet, mean sea level)
- (665.8) Groundwater Elevation Not Used For Contouring
- Groundwater Surface Contour (Dashed where Inferred)

NG - Not Gauged

Contour Interval = 0.5 Foot; varies at production wells

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12420 Milestone Center Drive
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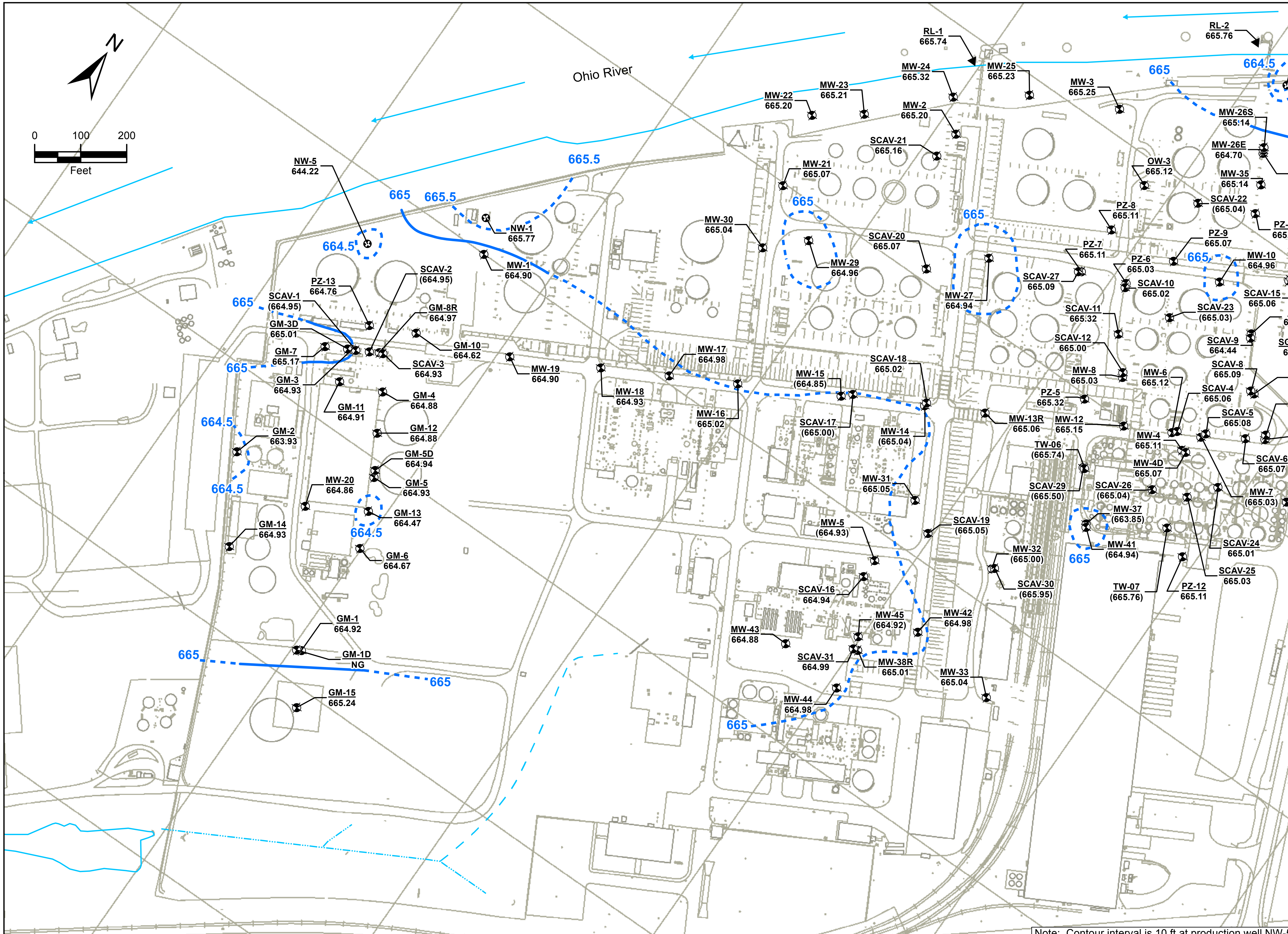
\Station_171297\MXD\Station_171297_gwelev_2_2017.mxd
Date: 8/29/2018
GIS: MS Checked: AC

Figure 2-2
Groundwater Surface Contour - June 5, 2017
Former Quaker State/Ergon Refinery
Newell, West Virginia



Legend

- ▲ River Water Gauging Station
- Monitoring Well
- Production Well
- 663.5 Groundwater Surface Elevation (feet, mean sea level)
- (665.8) Groundwater Elevation Not Used For Contouring
- Groundwater Surface Contour (Dashed where Inferred)

NG - Not Gauged

Contour Interval = 0.5 Foot

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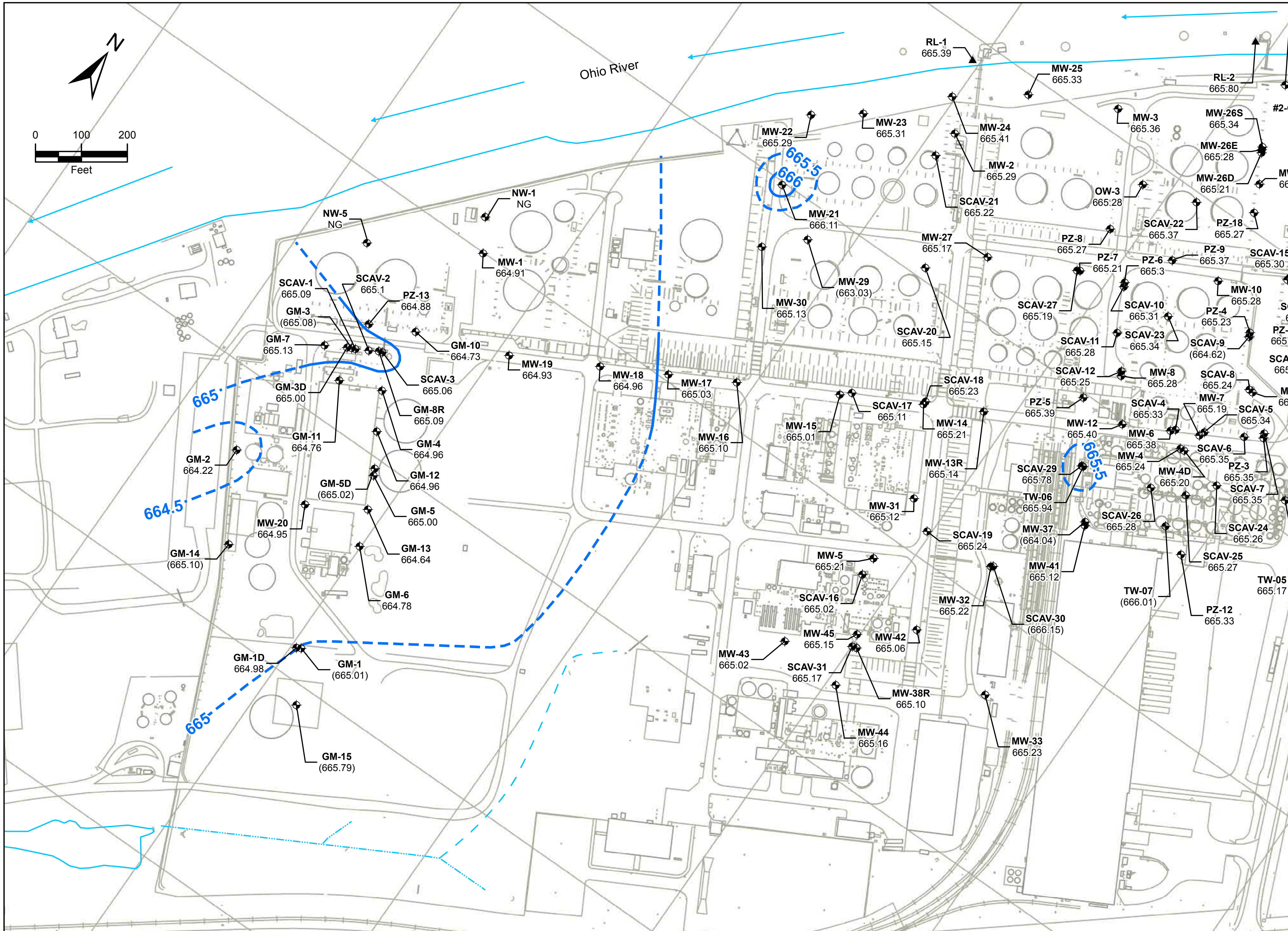
Date: 9/13/2018
GIS: MS Checked: KL

Figure 2-3
Groundwater Surface Contour - May/June, 2016
Former Quaker State/Ergon Refinery
Newell, West Virginia



Legend

665.33 Groundwater Elevation (feet, mean sea level)

(666.01) Groundwater Elevation Not Used For Contouring

Groundwater Surface Contour (Dashed where Inferred)

NG - Not Gauged

Contour Interval = 0.5 foot

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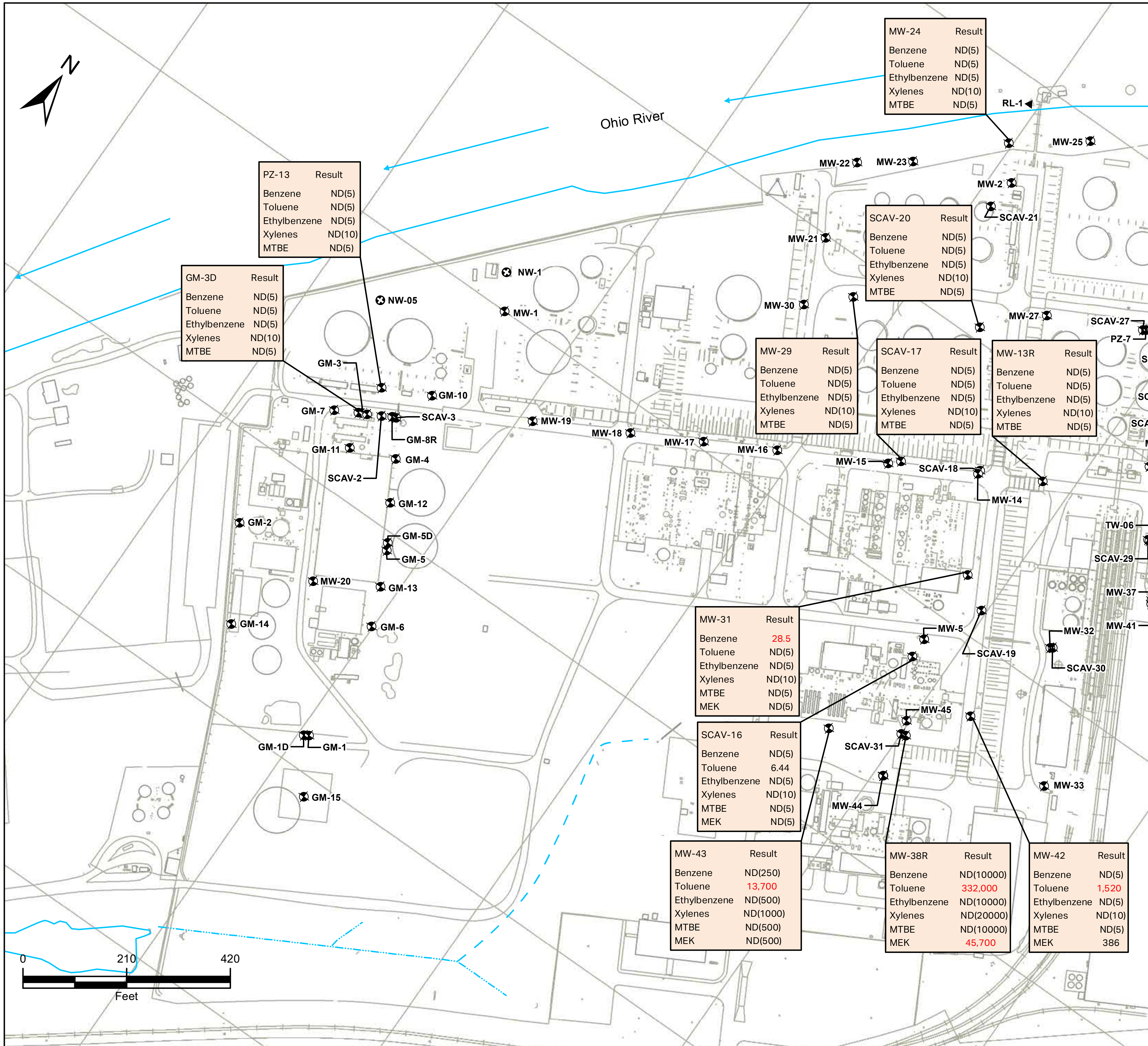
File: Q:\Projects\TechSol\GIS\Projects\Shell\Station_171297\MXD\Station_171297_gwelev_3Q15_v10.0.mxd
Date: 09/14/2015
GIS: AB Checked: CC

Figure 2-4
Groundwater Surface Contour - June 2015
Former Quaker State/Ergon Refinery
Newell, West Virginia

18_2



Legend

▲ River Water Gauging Station

Monitoring Well

Production Well

Result = Detected Concentration (µg/L)
ND(5) = Not Detected (Reporting Limit [µg/L])
J = Estimated Value

Screening Values:

Screening Value Exceedence in Red

Benzene: 5 µg/L
Toluene: 1,000 µg/L
Ethylbenzene: 700 µg/L
Total Xylenes: 10,000 µg/L
Methyl tert-Butyl Ether(MTBE): 14 µg/L
MEK: 560 µg/L

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File:Q:\Projects\TechSol\GIS\Projects\Shell\Station_171297\MXD\Fig2-5_Station_171297_DissolvedPhaseConcentrations_June2018_2.mxd
Date: 06/29/2016
GIS: MS Checked: AC

Figure 2-5
Dissolved Phase Concentrations in Groundwater - June 2018
Former Quaker State/Ergon Refinery
Newell, West Virginia

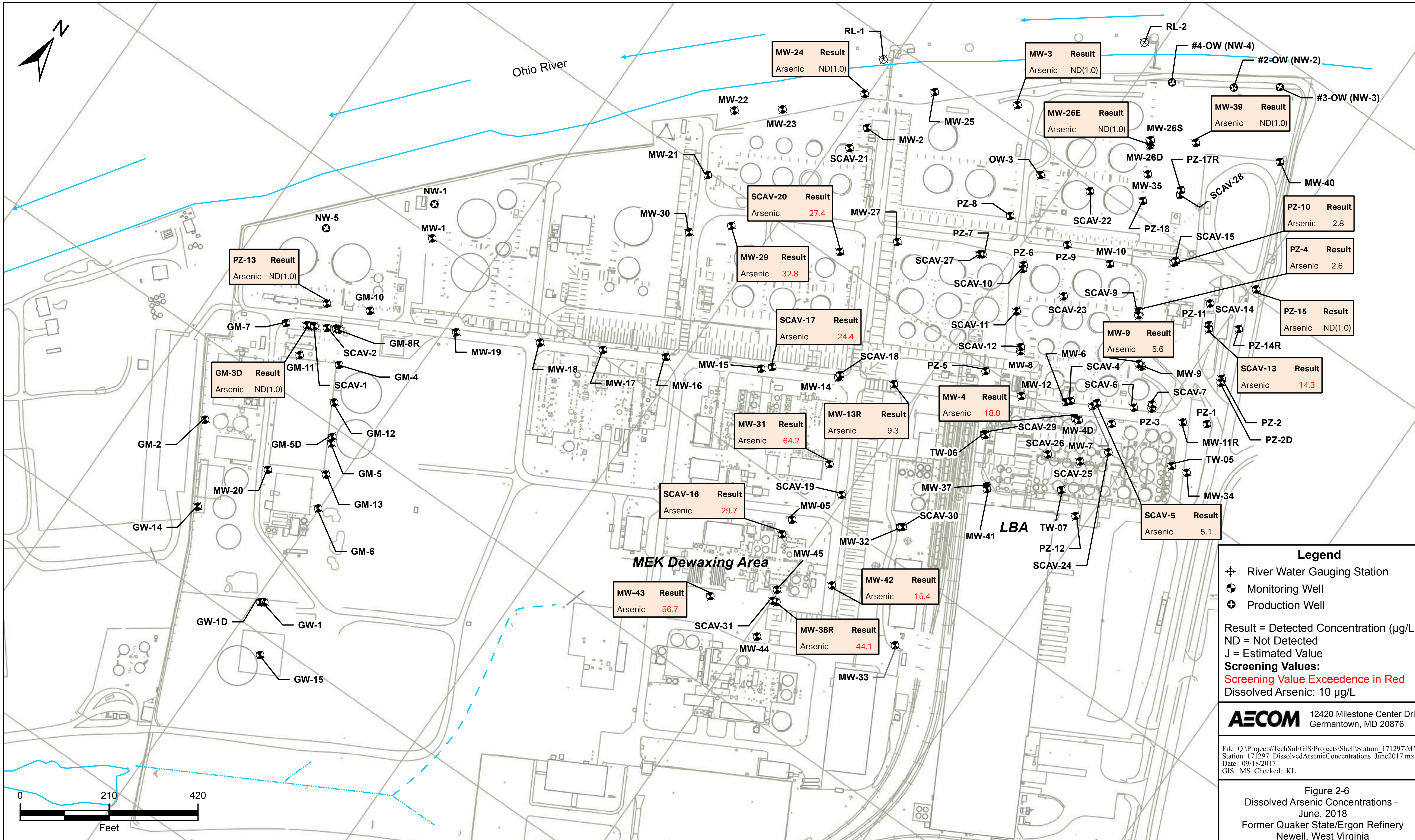
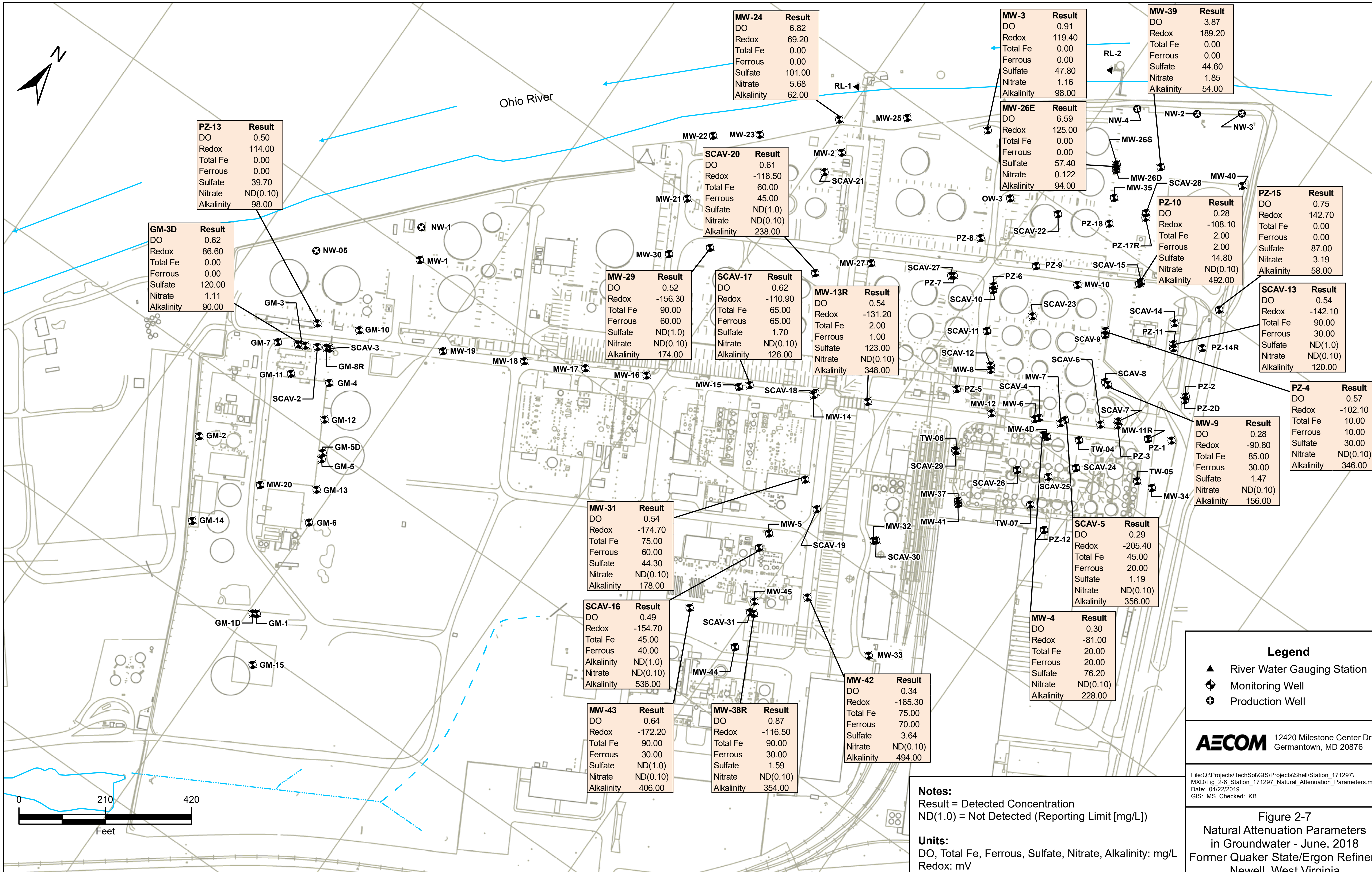


Figure 2-6
Dissolved Arsenic Concentrations - June, 2018
Former Quaker State/Ergon Refinery
Newell, West Virginia



Legend

- ▲ River Water Gauging Station
- Monitoring Well
- Production Well

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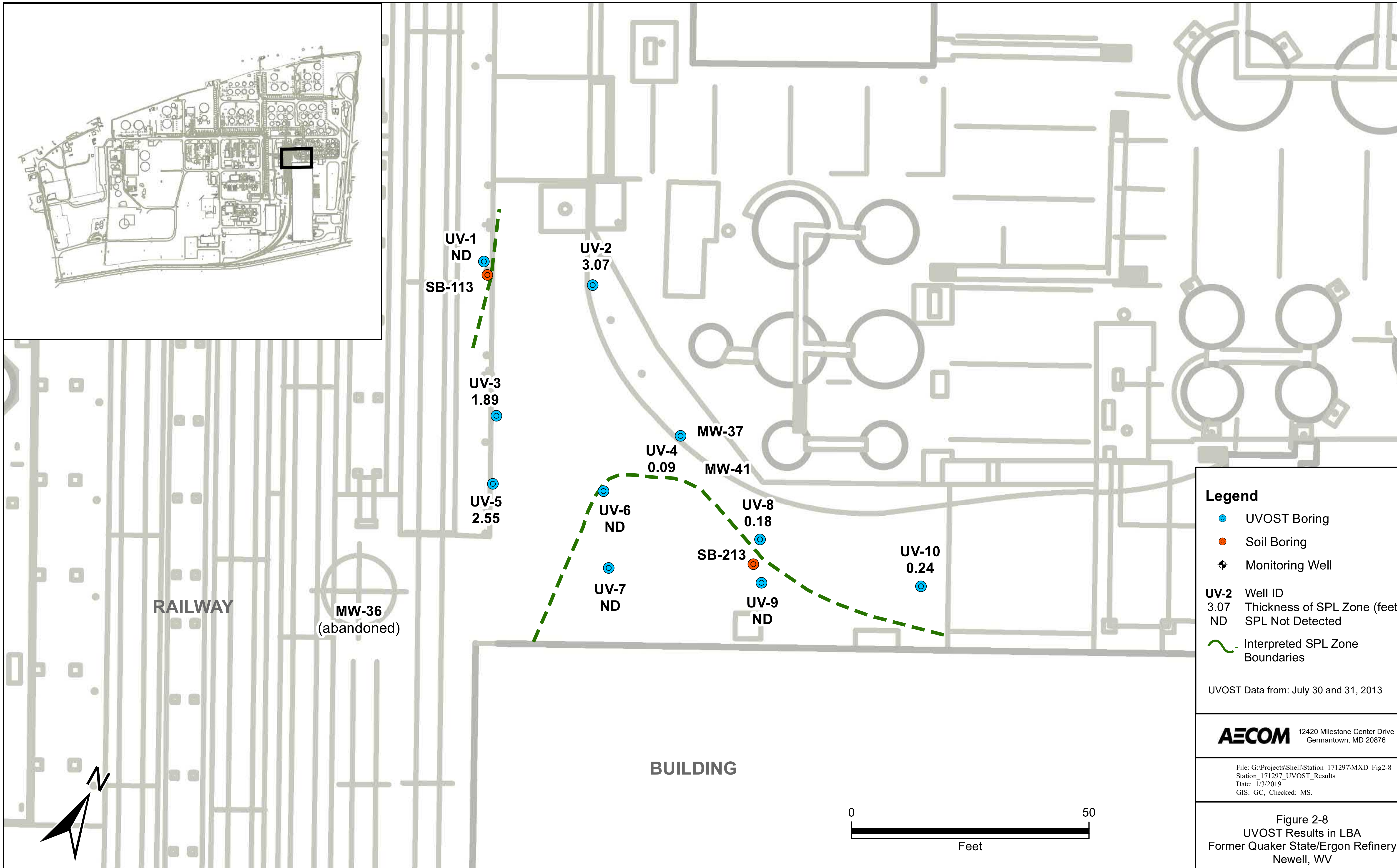
File:Q:\Projects\TechSol\GIS\Projects\Shell\Station_171297\MXD\Fig_2-6_Station_171297_Natural_Attenuation_Parameters.mxd
Date: 04/22/2019
GIS: MS Checked: KB

Notes:
Result = Detected Concentration
ND(1.0) = Not Detected (Reporting Limit [mg/L])

Units:
DO, Total Fe, Ferrous, Sulfate, Nitrate, Alkalinity: mg/L
Redox: mV

Figure 2-7
Natural Attenuation Parameters
in Groundwater - June, 2018
Former Quaker State/Ergon Refinery
Newell, West Virginia



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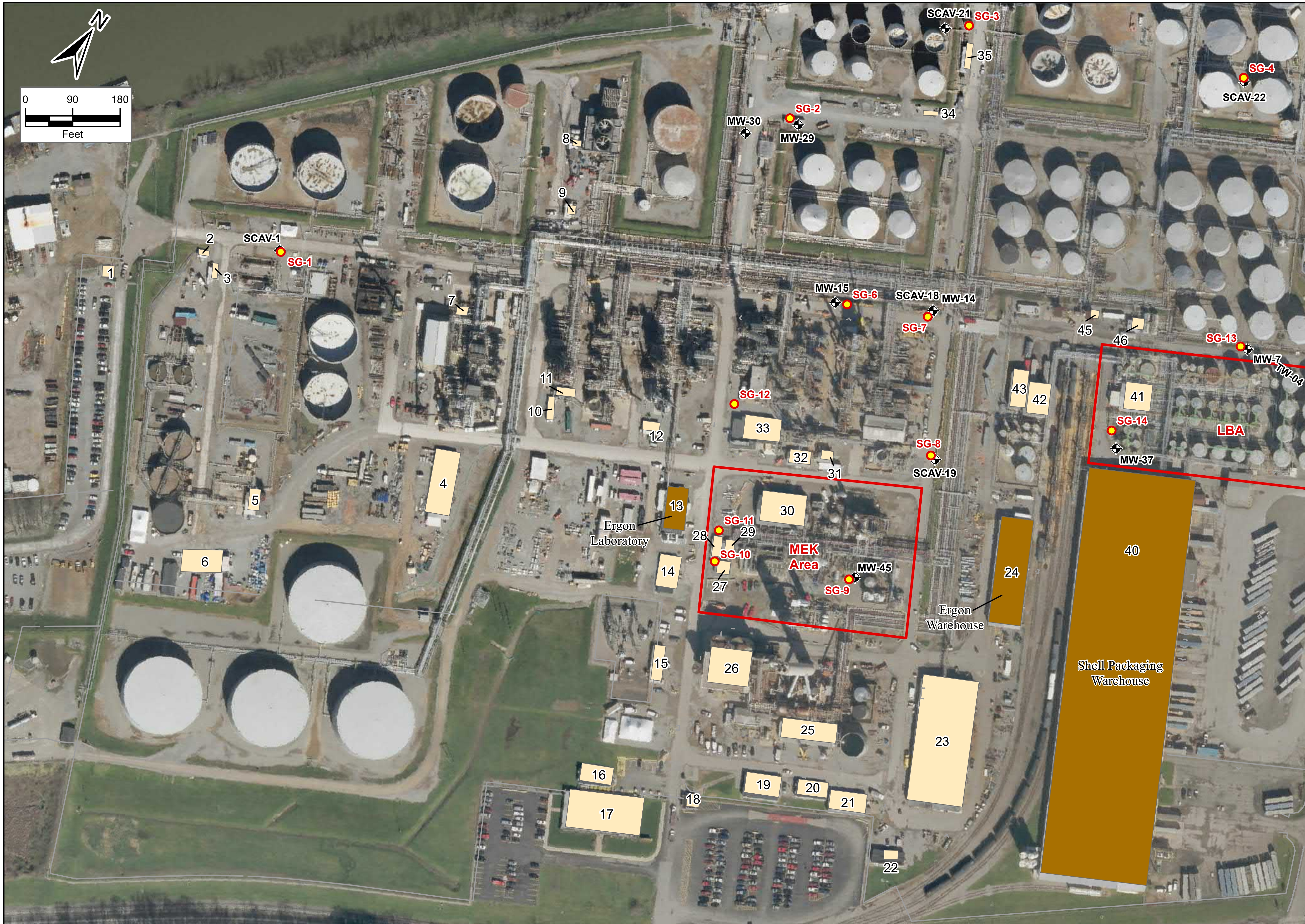
File: G:\Projects\Shell\Station_171297\MXD_Fig2-8_Station_171297_UVOST_Results
Date: 1/3/2019
GIS: GC, Checked: MS.

Figure 2-8
UVOST Results in LBA
Former Quaker State/Ergon Refinery
Newell, WV

Figure 2-9

Locations of Interior Sub-Slab Soil Gas Points
Former Quaker State/Ergon Refinery
Newell, WV



Legend

25	Building with Building No.
	Building Selected for Sampling
SG-1	Exterior Sampling Location
	Existing Monitoring Well

1 inch = 180 feet

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Q:\Projects\TechSol\GIS\Projects\Shell\Station_171297\MXD\2016\Fig2-10_Station_171297_ExteriorSoilGasSamplingPoints_Dec2015_v10.mxd
Date: 2/10/2016
GIS: AB Checked: KL Senior: BL

Figure 2-10

Locations of Exterior Soil Gas Sampling Points
Former Quaker State/Ergon Refinery
Newell, WV

3 Objectives of Corrective Measures

Corrective Action Objectives (CAOs) for corrective measures alternatives provide the basis for a decision-making framework that guides a practicable and reasonable approach to address and manage affected media and SPL at large sites with petroleum releases, such as the Refinery. CAOs are broad objectives with endpoints which are specifically identified for each CAO to provide measurable milestones toward the progress of meeting the endpoint criteria. CAOs were chosen based on guidance from the Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action (EPA, 2004). CAOs for this project are the short-term protection goals and the final restoration goal.

Short-term goals are related to exposure risks to humans and offsite migration of groundwater COCs and that they are not occurring. EPA developed two facility-wide “environmental indicators” to help monitor progress in achieving short-term protection goals. The two environmental indicators (EIs) are called “Current Human Exposures Under Control” and “Migration of Contaminated Groundwater Under Control.” Short-term goals for the site were prepared to satisfy these two EIs.

Per RCRA guidance, final goals are those that protect human health and the environment, and return groundwater to its maximum beneficent use, as applicable. The final goal should also control the source of the release so as to reduce or eliminate, to the extent practicable, further releases of hazardous waste or hazardous constituents that may pose a threat to human health and the environment. At sites where returning impacted groundwater to its maximum beneficial use is not technically practicable, facilities are expected to prevent or minimize the further migration of dissolved COCs, prevent exposure to the impacted groundwater, and evaluate further risk reduction (EPA, 2004).

3.1 Corrective Action Objectives

The CAOs for different media at the facility are summarized below:

3.1.1 Soil

The HHRA (AECOM, 2017) determined exposure to site soil did not cause an unacceptable risk (unacceptable is defined as Carcinogenic Target Risk (TR) greater than 1 x 10^{-4} and Target Hazard Index (HI) greater than 1.0) to current and future site workers and ecological receptors; therefore, remedial action to address soil is not warranted. A residential scenario was not evaluated due to the site’s intended long-term industrial use. An environmental covenant is planned that will include a land use restriction to prohibit any future residential use of the site. CAOs for soil are:

Short-term Goals

- Protection of human health from unacceptable exposure (unacceptable is defined as TR greater than 1 x 10^{-4} and HI greater than 1.0) to COCs in soil.
- Manage future Facility use to prohibit residential land use within the property boundary.

3.1.2 Groundwater

Short-term Goals

- Protection of human health from unacceptable exposure (unacceptable is defined as TR greater than 1 x 10^{-4} and HI greater than 1.0) to dissolved-phase COCs in groundwater.
- Protection of human health and the environment (including the Ohio River) from unacceptable exposure to dissolved-phase COCs in groundwater migrating offsite.
- Achieve stable or decreasing concentrations of groundwater COCs downgradient of onsite source areas (MW-31, MW-38R, and MW-42)

Final Goal

- Restore groundwater to drinking water standards, where necessary and feasible.

3.1.3 SPL in Groundwater

The HHRA determined that the potential for a construction worker to accidentally contact SPL in groundwater is negligible because groundwater at the site is present at depths ranging from 13 to 24 feet bgs. The depth of any hypothetical future excavation was assumed to be approximately 12 feet bgs. CAOs for SPL in groundwater are:

Short-term Goals

- Recover SPL to the maximum extent practicable
- Achieve a stable or decreasing SPL footprint

3.2 Achieved Corrective Action Objectives

The short-term CAOs (EPA's environmental indicators) outlined in **Section 3.1** that have been successfully achieved for soil, groundwater, and SPL prior to completion of this CMS are as follows:

- Soil: Achieve protection of human health (for the current/future site workers) from unacceptable exposure to COCs in soil.

The HHRA (AECOM, 2017) determined exposure to site soil did not cause an unacceptable risk to current and future site workers and ecological receptors, as described in **Section 2.4**.

- Groundwater: Achieve stable or decreasing concentrations of groundwater COCs downgradient of onsite source areas (MW-31, MW-38R, and MW-42)
- Groundwater: No offsite migration of dissolved-phase COCs that could cause unacceptable risk to human health or the environment

Dissolved-phase concentrations of COCs have been stable or declining over time in all wells sampled at the Refinery, as described in **Section 2.2.2.4**. Declining chemical concentrations further supported NA is occurring at the site (**Section 2.2.2.5**). Dissolved COC concentrations exceeding screening values are detected in only the central portion of the refinery greater than 500 feet from the property boundary and offsite migration is not occurring, as described in **Section 2.2.2.3**.

- SPL: Recover SPL to the maximum extent practicable

SPL was deemed recovered to the maximum extent practicable based on interim remedial actions using total fluids recovery and sorbent socks from 1994 to 2012. Further, SPL baildown testing completed in 2013 indicates SPL is not recoverable, as described in **Section 2.2.3.3**, based on SPL transmissivity results being less than the 0.8 foot^2/day ITRC criterion (ITRC, 2018) for all wells apart from MW-41. SPL transmissivity at MW-41 was calculated to be more than the ITRC criterion during the summer and fall testing seasons and lower than the ITRC criterion during the winter and spring testing seasons. The change between seasons is a result of fluctuating groundwater levels. SPL recovery using hydraulic means is therefore not recommended, as it is unlikely that SPL active recovery would support sufficient SPL depletion due to fluctuating groundwater elevations. This conclusion is supported by historical recovery efforts from the interim remedial actions.

- SPL: Achieve a stable SPL footprint

The three main areas of SPL along with five isolated occurrences of SPL at the Refinery have been generally stable to decreasing in size, as presented in **Section 2.2.3.2**.

3.3 Possible Action Levels for Soil and Groundwater

No action levels are necessary for soil, as exposure does not present unacceptable risk to industrial site receptors and no corrective action is planned for site soil. The EPA MCLs and RSLs could be used to provide the possible action levels for groundwater at a site under the RCRA Corrective Action program. No action levels exist for SPL.

MCLs could be used as action levels for groundwater at the site and, where MCLs are not available, the RSLs for residential tap water with TR of 1×10^{-5} and HI of 1 (EPA, 2019). Per EPA guidance, RSLs for action levels should be between a TR of 1×10^{-4} and 1×10^{-6} and an HI of 1 or less (EPA, 2004). The following MCLs or RSLs could be used as possible action levels for COCs in site groundwater as warranted:

Table 3-1: Possible Groundwater Action Levels

Analyte	Regulatory MCL/RSL (µg/L)
Arsenic	10 (MCL)
Benzene	5 (MCL)
Toluene	1,000 (MCL)
Ethylbenzene	700 (MCL)

Analyte	Regulatory MCL/RSL (µg/L)
Total Xylenes	10,000 (MCL)
MTBE	140 (RSL for TR $1x10^{-5}$)
MEK	5,600 (RSL for HI 1)

3.4 Compliance Points

Points of compliance (POC) are locations that represent where the CAOs are achieved, as determined applicable to the selected remedy. For a final goal of returning groundwater to its maximum beneficial use, per RCRA protocol, the point of compliance will be throughout the area of impacted groundwater. If it is determined that the groundwater cannot be restored to drinking water standards because of technical impracticability (TI), the POC should be a boundary outside of the area of impacted groundwater that is protective of site receptors, as determined necessary. In the case of the TI determination, the MCLs/RSLs would not apply inside the TI determination area and the POC would be the areas that are not included in the TI determination, if and when necessary.

3.5 Remedial Endpoints

Current conditions at the Refinery and the proposed CAOs are used as a basis to determine the remedial endpoints for each affected media as related to a potential alternative. If a remedial endpoint would apply, a remedy would be considered completed when the remedial endpoints are achieved. Attainment of the soil CAO will be the main endpoint for the soil. For the dissolved COCs in site groundwater, the proposed remedial endpoint is the demonstration of achieving the groundwater-specific CAOs. Attainment of the SPL CAOs will be the main endpoint for the SPL.

During the alternative evaluation process (**Section 6**), particular alternatives, as applicable, are evaluated to determine whether they have a likelihood of meeting a proposed remedial endpoint.

4 Technical Impracticability Evaluation for Groundwater

Restoration of groundwater to drinking water standards at an investigated site is one of the remedial objectives of the RCRA program. In certain situations, remediation of impacted groundwater to drinking water standards may be technically impracticable from an engineering perspective. As discussed in EPA's *1993 Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration (the TIE Guidance),* a number of factors exist that can inhibit groundwater restoration, which include hydrogeologic conditions, COC-related factors, and site operations. The guidance outlines an approach to evaluating the technical impracticability of implementing active remedial methods to attain drinking water standards in impacted groundwater at the site. This TIE is conducted in accordance with the TIE guidance to request a TI determination for groundwater at the site.

4.1 Components of TI Evaluation

The TIE guidance (EPA, 1993) contains six primary components that include:

- Identifying specific groundwater standards for which TI determinations are sought;
- Evaluating the spatial area over which the TI determination may apply;
- Developing a conceptual model that describes the geology, hydrogeology, groundwater COC sources, and fate and transport of the COCs;
- Evaluating the restoration potential of the site, including data and analyses that support that attainment of groundwater standards is technically impracticable from an engineering perspective;
- Estimating the cost of the existing or proposed remedy options, including construction, operation, and maintenance costs; and
- Presenting any additional information or analysis that EPA deems necessary to the TI evaluation.

The primary factors that may inhibit groundwater restoration to drinking water standards include:

- Hydrogeologic limitations such as complex and/or low permeability groundwater zones, fractured bedrock, and other factors that make in-situ treatment of impacted groundwater difficult to reliably achieve;
- Source-related factors that may limit the success of an extraction or in-situ treatment process (such as type and volume of chemical release(s), presence of free-phase SPL);
- Characteristics and distribution of COCs that cause implementation of active remedial methods s to be unreasonable, illogically, and/or costly (spatial location, mass of dissolved COCs in groundwater, and ability to use an effective remedy);
- Site-related factors including facility infrastructure and operations, and safety concerns at the site and construction of a remedy; and
- Reliability of a remedial and/or treatment method to attain the restoration goal, and the scale of the remedial action in consideration of cost/benefit.

Of note is that the EPA term “engineering perspective” refers to factors such as feasibility, reliability, scale or magnitude of a project, and safety.

4.2 Groundwater Standards

The following established MCLs or RSLs (residential tap water with TR of 1×10^{-5} and HI of 1 [EPA, 2019]) are used as groundwater standards for COCs in site groundwater:

Table 4-1: Drinking Water Standards for Site Groundwater COCs

Analyte	Regulatory MCL/RSL (µg/L)
Arsenic	10 (MCL)
Benzene	5 (MCL)
Toluene	1,000 (MCL)
Ethylbenzene	700 (MCL)
Total Xylenes	10,000 (MCL)
MTBE	140 (RSL for TR 1×10^{-5})
MEK	5,600 (RSL for HI =1)

4.3 Spatial Extent of the TI Determination

As described in the TIE Guidance, the area where the EPA determines that groundwater restoration is technically impracticable and over which the decision applies (the “TI zone”) may include a portion of, or all portions of the impacted groundwater that is anticipated to not be able to meet the drinking water standards with active-type groundwater remediation methods. A TI zone at the facility may also include areas of existing non-recoverable SPL that would make restoration of groundwater for drinking water purposes difficult or impossible to achieve.

For the subject facility, a TI determination is requested for the two areas as presented on **Figure 4-1**. These two proposed TI zones include all monitoring wells with dissolved phase COC concentrations greater than their MCLs/RSLs and observed residual SPL based on the last ten years of site monitoring. The boundaries of the TI zones are at least 100 feet from wells with dissolved phase COCs that exceeded their regulatory standards and from wells with measurable SPL. The proposed “TI zones” are within the current boundaries of the site. The larger TI zone at the eastern and central parts of the Refinery are related to the presence of dissolved VOCs and arsenic, and of SPL. The smaller western area near the API separator includes wells GM-7, PZ-13, and SCAV-1 and is related to the presence of non-recoverable residual SPL in the groundwater. The base of the TI zone for the site is proposed as the bottom of uppermost groundwater zone that extends to approximately 605 feet above mean sea level (approximately 70 feet below site ground surface), which will fully encompass known impacted groundwater and SPL.

4.4 Conceptual Site Model

Conceptual Site Model information are presented in the following sections of this report: **Section 2.1**: geology and hydrogeology, **Section 2.2**: groundwater COC sources, **Section 2.3**: fate and transport of COCs.

CSM conclusions are summarized below:

- The depth to the groundwater surface is approximately 8 to 26 feet bgs at the facility. The shallower groundwater surface exists beneath the southern corner of the Refinery, and the deepest groundwater surface occurs in the northern corner of the site. The primary materials of the shallow alluvial groundwater system beneath the Refinery are coarse deposits of sand and gravel in the eastern portion of the site and fine to medium sand in the western portion of the site.
- The groundwater surface beneath the majority of the site is very flat, with an approximate average horizontal gradient of 0.0003 feet per foot.
- Five onsite water production wells currently exist at the Refinery (NW-1 to NW-5) to produce water for non-potable, industrial uses. The extraction of groundwater from the five production wells does not influence the areas of impacted groundwater or SPL when the wells are operated, and based on site data, is not causing migration of the COCs.
- Dissolved VOC COC concentrations exceeding screening values are detected in only the central portion of the refinery greater than 500 feet from the property boundary and offsite COC migration is not occurring, as described in **Section 2.2.2.3**.
- Natural attenuation parameters support that biodegradation of petroleum hydrocarbons is occurring in site groundwater, which is also evident by the substantially reduced concentrations of COCs in site groundwater.
- Total iron concentrations in the range of 30 to 150 mg/L with negative redox values exist in the impacted groundwater at the facility.
- Fate and transport modeling show that the “steady-state” plumes with benzene or toluene concentrations exceeding the MCLs of 5.0 µg/L and 1.0 mg/L, respectively, are predicted to extend only approximately 110 feet downgradient of their source areas in central part of the facility. Using a depleting source for the model, natural attention processes are predicted to degrade benzene and toluene to below their MCLs under natural conditions over time; possible remaining solubilizing SPL sources in certain areas could impede the NA of the petroleum COC to achieve final groundwater goals.
- The SPL footprint at the Refinery is well-defined and has remained similar as demonstrated for at least the past 8 years. SPL data indicate the footprint is not expanding. The largest areas of SPL are located near the center of the site, a significant distance away from any offsite receptors, including the river. The sources of the SPL are from historic operations at the Refinery at a several areas. Minor fuel oil releases occurred in the vicinity of well SCAV-19, north of the MEK dewaxing area, in the small areas of the northern tank areas, and at the western API separator.

The SPL in several wells in the LBA was caused by a suspected historic lubricating oil releases from prior to 2004; albeit, there are no reported releases from the tanks and other structures in the LBA. No known or suspected on-going SPL releases exist at the Refinery. Since the releases have abated, the SPL head has dissipated and cannot drive further SPL migration.

- SPL was deemed recovered to the maximum extent practicable based on interim remedial actions using total fluids recovery and sorbent socks from 1994 to 2012. Further, SPL baildown testing completed in 2013 indicates SPL is not recoverable, as described in **Section 2.2.3.3**. The three main areas of SPL and the five isolated occurrences of SPL at the Refinery have been stable to decreasing in size, as presented in **Section 2.2.3.2**.

4.5 Evaluation of Restoration Potential

Several factors will affect the restoration of impacted groundwater to MCLs/RSLs at the site. The three main factors include the properties and distribution of the dissolved COCs, the presence of SPL, and site infrastructure and operations.

Based on groundwater data collected since 2013 timeframe, dissolved VOCs (mainly benzene, toluene, and MEK) in site groundwater exceed their MCLs/RSLs in two areas in the central part of the refinery - area near wells MW-31 and SCAV-18 and in the MEK Dewaxing area near wells MW-38R and MW-42. Dissolved arsenic at concentrations greater than its MCL has been detected in the shallow groundwater of the central part of the site and to a limited extent beneath the eastern part of the site.

4.5.1 Properties and Distribution of Dissolved COCs

The properties and distribution of the dissolved COCs to be restored to MCLs/RSLs need to be considered for the evaluation of groundwater restoration. The factors of main interest are the source area concentrations, COC mass, and the extent of the dissolved COC footprint. In the MEK Dewaxing area, toluene and MEK exist in the subsurface at and near the groundwater table. Free-phase toluene/MEK are currently measured in well MW-45 and were once present to a lesser degree in other nearby wells. Concentrations of toluene and MEK are approximately one to two orders of magnitude greater than their MCLs/RSLs in well MW-38R. In the MEK Dewaxing area, the residual SPL and elevated toluene and MEK concentrations will preclude successful attainment of the MCLs/RSLs for groundwater in this area with active remediation in the near term.

With the dissolved arsenic in groundwater, arsenic is a naturally occurring constituent in the subsurface formation that is solubilized by the reduced (anaerobic environment) groundwater conditions where hydrocarbons exist or once existed. The dissolved arsenic of interest has a site-wide natural in-situ source that will be difficult to remove from or treat in the subsurface. In addition, the arsenic concentrations greater than its MCL are not a threat to discharge to the Ohio River and there is no offsite migration of arsenic at concentrations greater than its MCL. Importantly, after the petroleum hydrocarbons are attenuated, the natural attenuation of arsenic will occur as the natural aerobic conditions of the site groundwater is restored (Brown, et al, 2010).

The arsenic will be re-oxidized to the less soluble forms and will cause iron to become iron oxyhydroxides that will bind the arsenic to the formation particles and subsequently become mineralized. The natural attenuation of arsenic is associated with the attenuation of the dissolved hydrocarbon COCs in the site groundwater; based on this condition, natural attenuation of the dissolved arsenic is a reasonable and feasible alternative to lower its concentrations in the groundwater to the ambient (background) dissolved arsenic concentration, which is interpreted to be less than its MCL of 10 ug/L.

4.5.2 Presence of Non-Recoverable SPL

With regards to the presence of non-recoverable (residual) SPL, three main areas of SPL and five isolated occurrences of SPL exist at the Refinery. Although the SPL footprint has been generally stable to decreasing in size, the subsurface SPL can be a possible source material to release dissolved constituents to groundwater over long periods of time (EPA, 1993). The SPL in the MEK Dewaxing area (toluene and MEK) is a source in this area and the SPL (gasoline and lubricating oil) in the area north of the Dewaxing area is a suspected source of COCs to the well MW-31 area. Importantly, SPL at the site has been removed to the maximum extent practicable. Continued recovery efforts are not expected to remove the remaining SPL in the groundwater any faster than natural dissolution of the SPL. Some SPL will remain in the subsurface formation near its release locations. While non-recoverable SPL remains in the subsurface, restoration of groundwater for drinking water purposes is technically impracticable to achieve.

The interim remedial actions completed to assess the recovery of SPL in groundwater were discussed in **Section 2.5**. Information acquired via several SPL recovery methods indicate only minimal SPL recovery can be achieved at the site and is believed to have a negligible affect to reduce the overall amount of the SPL in the subsurface. SPL recovery via total fluid pumps in site wells used from 1994 to 2012 had minimal effects in changing or improving the condition of the site. Thus, SPL recovery was discontinued in 2012. Recent site conditions did not support the reactivation of the existing total fluids recovery system. Based on the testing of two LBA wells with higher SPL accumulations, use of EFR was determined to be an ineffective method to recover SPL at the site. Results of manual bailing of site wells with measurable SPL for several years indicate minimal amounts of recovered SPL and do not suggest potential for greater SPL recovery via hydraulic means. Manual SPL recovery has had a negligible effect to reduce the overall mass of the SPL in the subsurface. These conditions exist in wells in the western API separator area where manual bailing was performed with negligible SPL recovery. The occurrence of SPL in a well is not a reliable metric of recoverability.

In addition to the previous SPL recovery efforts, a series of SPL baildown tests conducted in four wells with SPL accumulations (MW-15, MW-41, SCAV-19, and SCAV-29) indicated SPL is not recoverable, as described in **Section 2.2.3.3**. SPL recovery using hydraulic methods is therefore technically impracticable. This conclusion is supported by historical recovery efforts from the interim remedial actions.

4.5.3 Site Infrastructure and Operation Constraints

Active remedial technologies to address site groundwater, such as a groundwater pump and treat (P&T) system, air sparging, or excavation of media containing SPL, are to be considered for groundwater restoration, yet their construction and operation and maintenance (O&M) will be significantly constrained and complicated by the existing infrastructure and current land use/operations at the active refinery. These onsite conditions make the use of the active remedial technologies technically impracticable for groundwater restoration. A P&T system is not considered as an effective remedy for groundwater in the central and possibly eastern parts of the site to remove low-level dissolved COCs and arsenic because their installation would cause site operation disruption, affect or be affected by existing infrastructure, and have substantial safety concerns. As an active refinery, the facility is heavily developed, and buried and overhead lines are present throughout the facility. Excavation of the subsurface to remove impacted media or to construct a remediation system could compromise the integrity of surrounding infrastructure including storage tanks and product delivery pipelines. Certain areas of the refinery are off limits to construction or the involvement of non-site staff. In particular, the significant above ground and below ground infrastructure in the MEK Dewaxing area of the Refinery is a substantial hinderance to successful restoration in this area. Additionally, invasive activities would cause significant business interruption at the active facility and the community (defined as the site operator Ergon West Virginia Inc [EWVI]). Due to site infrastructure and use, active remedies would be difficult to safely and effectively construct to address dissolved COCs and SPL for groundwater restoration.

Worker safety is an engineering component that must also be evaluated for the use of an active remedial method at a site, especially an active refinery or chemical plant. In order to construct a groundwater P&T system, in most cases, outside workers would be used to install the system and to also perform the system O&M. The presence of many below ground and above ground utilities pose a safety risk that must be addressed to avoid a utility strike and/or a release/spill of material. Other structures at the Refinery such as the refinery distillation equipment and high-pressure lines, and storage vessels/tanks as well as facility operations represent safety hazards for onsite work. Safety of the various workers is more of a concern with this type of system as compared to a more passive remedial alternative and is another criterion for the TI determination per the engineering perspective.

4.5.4 Other Factors for TI Determination

The reliability and effectiveness of an active remediation method to attain the groundwater restoration to MCLs/RSLs is a factor related to the its technical implementability. For example, the removal of dissolved arsenic from extracted groundwater, generated by a possible groundwater P&T system, would require a different treatment technology as compared to VOC removal from groundwater. This requirement would add to the complexity of a remedial system, make it more unreliable, and require significant long-term maintenance, thus, adding to the weight of the overall method being technically impracticable. Groundwater remedial systems including groundwater P&T and air sparging are susceptible to biofouling and scaling issues that can be significant enough to terminate the use of the method. The iron-rich and bacteria-rich groundwater of the impacted COC areas and presence of SPL at the subject Refinery could cause biofouling and scaling, resulting in substantial O&M issues and costs that will impede the reliability and effectiveness of the remedial methods. In addition, with many active remedial methods, the degree of chemical concentration rebound could be an issue due to hydrogeologic conditions and COC characteristics; such could be the case for the higher COC concentrations and source mass in the MEX Dewaxing area.

A review of the timeframes to attain groundwater goals is also considered for the TI evaluation for the facility. Overall, the timeframe of an active or passive remedial method to achieve the final groundwater goal is an estimation with uncertainties. Based on remedial experience, the timeframe for a possible active remedial method such as groundwater pump and treat system, if to be installed as a corrective alternative, to attain the MCLs/RSLs for impacted groundwater is an estimated range of 20 years to 40 after installation of the system to potentially attain the benzene MCL in groundwater of the central MW-31/SCAV-18 area. Rebound of chemical concentrations in partially remediated groundwater could be an issue that increases the timeframe of addressing the dissolved COCs. Importantly, the use of an active method such as groundwater pump and treat in the MEK Dewaxing area has been deemed technically impractical for several reasons discussed in **Sections 4.5.** Natural attenuation of dissolved COCs in site groundwater is predicted to be achieved in certain areas within 25 to 50 years, presuming a depleting source concentration; this prediction could be impeded by source material in the area.

4.6 Cost Estimates

Possible corrective measures alternatives for impacted groundwater will be based on facility conditions, industry knowledge, and previous application at the Refinery or at similar sites. Estimated costs of passive-type and active-type remedial alternatives could vary from less than $50,000 annually for several years to up to approximately $3.6 million over an estimated 20-year period.

The implementation of a Monitored Natural Attenuation (MNA) alternative for groundwater is estimated at $40,000 per year of monitoring. An MNA program could have an estimated total cost in the range of $250,000-$300,000 over a 20-year period. Although considered impractical and not warranted for the subject facility, the cost to design, plan, and install a possible groundwater pump and treat system for the central part of the site to address the dissolved VOCs is in the range of $400,000 -$600,000 for initial construction at the refinery with special construction requirements. With an annual operation and maintenance costs of approximately $150,000, the estimated cost to operate the system for twenty years could be approximately $2.3 million. Estimated total cost of the groundwater system could be in the range of $3.6 million. The long-term maintenance of the anticipated treatment system would be a substantial effort and could be subject to issues such as scaling and biofouling that would make the system operations unreliable. Of note, once an environmental covenant is implemented to prohibit residential use of the site and potable use of groundwater, the costly groundwater pump and treat system would not provide additional protection to human health and the environment.

For SPL, SPL skimming is estimated to cost approximately $275,000 for five years. No active remedy for SPL is expected to be effective at removing SPL from the subsurface; SPL has been already removed to the maximum extent practicable in consideration of site conditions.

4.7 Additional Information

Results of the HHRA, presented in **Section 2.4**, indicate that there is negligible potential for adverse effects to current and future worker receptors exposed to site media. Only the theoretical potable use of groundwater by hypothetical future adult and child residents yielded unacceptable potential risk. A residential scenario was not evaluated due to the site's intended long-term industrial use. An environmental covenant is planned with institutional controls (ICs) including land use limitations that the property will be used for industrial (non-residential) purposes only and to prohibit potable use of groundwater. The covenant and ICs will apply to the entire facility. Protection of human health and the environment would continue if the TI zone is approved and an environmental covenant is put in place.

4.8 Conclusions

The factors that will preclude the achievement of MCLs/RSLs for groundwater via an active-type remedy at the site in the proposed TI zones are as follows:

- Free-phase toluene and MEK in subsurface of MEK Dewaxing area acting as source material to groundwater and resultant high-level COC concentrations;
- Presence of natural site-wide in-situ arsenic in subsurface that becomes mobilized in impacted groundwater;
- Presence of non-recoverable residual SPL (potential source material) in several areas of site that contribute to presence of dissolved COCs;
- Complications with facility infrastructure and safety concerns with possible remedial construction efforts at an active refinery;
- Disruption of active remedy with facility operations;
- Reliability and effectiveness issues with groundwater P&T and/or air sparging systems due to substantial long-term O&M problems including biofouling and scaling and issues with more than one treatment system (VOCs and arsenic);
- Planned use of ICs to prevent unacceptable human health exposures at entire facility; and
- No off-site migration of dissolved COCs or SPL.

Based on the information presented in this report, a TI determination for the TI zone presented in **Figure 4-1** is requested for the site under the EPA's TI Guidance for groundwater restoration. The approval of the TI request is incorporated into the remaining sections of this CMS, as non-active remedies are identified and assessed to address site groundwater and the areas of SPL.

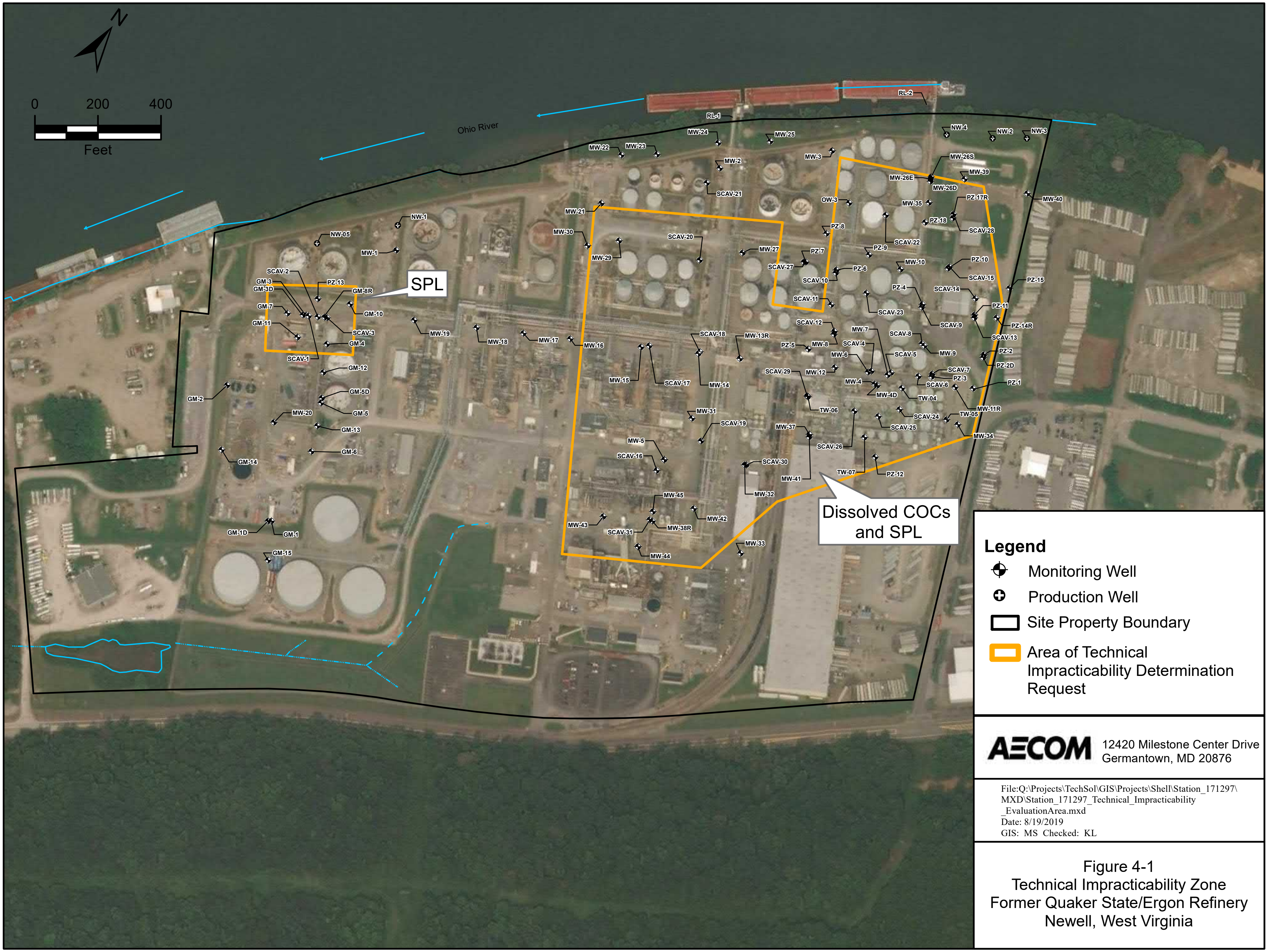

Figure 4-1
Technical Impracticability Zone
Former Quaker State/Ergon Refinery
Newell, West Virginia

5 Identification of Corrective Measures Alternatives

The purpose of this section is to identify potential corrective measures alternatives, which may be part of an alternative remedial strategy, to address the presence of COCs in site soil and for dissolved groundwater COCs and SPL in the subsurface of certain parts of the Refinery. The corrective measures alternatives outlined in this section are based on facility conditions, industry knowledge, previous application at the Refinery or at similar sites, and the CAOs.

If EPA determines that achieving drinking water standards associated with final goals is technically impracticable for the two proposed TI zones at the facility (as described in **Section 4**), an alternative remedial strategy can be pursued that will include alternatives which protects human health and the environment, is technically practicable, and is expected to achieve drinking water standards outside the TI zones.

The potential corrective measures alternatives were identified based on the above criteria (EPA, 2004). Alternatives that did not meet these criteria were omitted from consideration. Further, corrective measures alternatives that are unproven or experimental were also excluded from consideration in the CMS.

As indicated in **Section 3**, the HHRA determined that exposure to soil at the Refinery did not cause an unacceptable risk to human health of industrial site workers or ecological receptors; therefore, remediation of this media is not warranted. A residential scenario was not evaluated in the HHRA due to the site's intended long-term industrial use. Soil is included in the corrective measures alternatives screening process in order to address the potential risk to a hypothetical future resident.

The use of institutional controls (ICs) as part of an alternative and to support the short-term and final groundwater goals is presented in **Section 5.1**. Potential corrective measures alternatives for site soil, groundwater, and for SPL are described in **Sections 5.2** to **5.4**. Correct measures alternatives are evaluated in **Section 6.0**. Discussion on eliminated and retained corrective measures alternatives with final recommendations are presented in **Section 7.0**.

5.1 Institutional Controls

Institutional controls as non-engineered measures, such as administrative and/or legal controls, that minimize the potential for human exposure to constituents in site media by limiting land or resource use (EPA, 2004). Institutional controls may be used independently or with other technologies or process options to reduce or eliminate human exposure to soil, groundwater, SPL in the subsurface. This type of control includes land use limitations and restrictions contained in an environmental covenant or other agreement, permits or zoning practices, engineering controls (physical barriers), and/or site-specific institutional requirements. For soil, institutional controls will be needed to prevent future residential use of the site. For groundwater and SPL, institutional controls may be required if groundwater contains COCs above their respective drinking water standards (currently RSLs and MCLs) and for remaining SPL to be left in place.

An environmental covenant or a lease agreement is a legal document that defines acceptable land and groundwater uses for a site in consideration of its human and ecological receptors. Such agreements could contain possible restrictions on certain site operations (industrial vs. residential land use), prohibitions of groundwater use, or intrusive activities, such as soil excavation in particular areas, to eliminate potential exposure pathways.

Permits and zoning are managed through the appropriate regulatory agency. State and local governments can restrict unsafe land or groundwater use. Further, the facility can be zoned for light industrial and commercial use, which would eliminate residents as a potential receptor.

Engineering controls (or physical barriers) normally consist of fences or signs to limit site access or a structure to prevent exposure to impacted material.

Institutional requirements, such as standard operating procedures and training programs, limit employees' use and access to impacted media. Institutional requirements usually are combined with other institutional controls. For example, during soil excavations, personnel will wear appropriate personal protective equipment and will manage excavated soils appropriately. Through these requirements, human health is protected.

For the corrective remedy at the Refinery, an environmental covenant is planned for the site to define acceptable site use (industrial use only) and certain prohibition on groundwater use. In addition, a fence currently surrounds the Refinery and effectively protects trespassers from potentially impacted media. Institutional/administrative requirements, such as standard operating procedures and training programs, could also be possibly implemented, as determined necessary. These potential items are discussed further in **Section 7.1**.

5.2 Soil

A description of the potential corrective measures alternative for soil at the Site is presented below:

5.2.1 No Action with Institutional Controls for Soil

The HHRA (AECOM, 2017) determined exposure to site soil did not cause an unacceptable risk (unacceptable is defined as TR greater than 1×10^{-4} and Target HI greater than 1.0) to current and future industrial site workers and ecological receptors; therefore, remedial action to address soil is not warranted for these receptors. Institutional controls of this alternative will prohibit any future residential use of the site by limiting the site to industrial use only.

5.3 Groundwater

As presented in the TIE (**Section 4**), an evaluation of the groundwater and site conditions at the refinery indicates that active remediation of the areas of impacted groundwater and SPL for restoration to drinking water standards is technically impracticable nor warranted based on several factors.

A TI determination for the two TI zones (**Figure 4-1**) was requested from the EPA. Protection of human health and the environment would continue if the TI zone is approved and an environmental covenant is put in place. Thus, below are descriptions of potential corrective measures alternatives specifically for groundwater at the Site to meet the CAOs.

5.3.1 No Action with Institutional Controls

Using No Action, no efforts would be conducted to remediate or control groundwater at the site if the TI determination is approved for groundwater. This alternative would be applied across the entire site. As part of this alternative, institutional controls would be implemented at the entire Refinery property to require industrial use only and to eliminate potential human exposure to affected groundwater via the prohibition of potable groundwater use as part of the planned environmental covenant.

Importantly, natural attenuation processes are documented to exist and will continue in site groundwater to degrade dissolved COCs as they migrate from interpreted depleting source area. In addition to the observed declines of COC concentrations over years of time in site groundwater, certain groundwater conditions also provide evidence that NA is occurring, or that conditions are favorable for NA of the dissolved COCs. As a significant line of support in **Section 2.5**, a groundwater fate and transport model indicate that the benzene and toluene plumes exist in only a small area near or at a relatively minor distance downgradient of their source areas within the refinery boundaries, a significant distance from the Refinery property boundaries.

5.3.2 Monitored Natural Attenuation with Institutional Controls

MNA is a passive-type remedy that includes a variety of physical, chemical, and biological processes that, under favorable conditions, act without human intervention to reduce the mass, mobility, volume, or concentration of COCs in groundwater. These processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of subject COCs (EPA, 1999). The use of this process would address organic COCs in groundwater, such as the petroleum-related COCs at the subject refinery, and would be based on the approved TI determination to continue groundwater CAO compliance beyond the TI boundary. The EPA considers MNA an appropriate restoration option when the facility can demonstrate that the remedy is capable of achieving drinking water standards in a reasonable restoration timeframe (EPA, 2004).

In groundwater with stable, low-level, dissolved-phase, organic COCs and demonstrated NA with no or very limited source material, MNA usually is applicable as a remedial alternative and is not as susceptible to changes in permeability as other remedial alternatives. In many cases, MNA can be observed in both low and high permeability subsurface systems. MNA may also be used in conjunction with active remediation systems or as a final, follow-up corrective measure to address low-level residual impacts that otherwise would be untreatable through active remediation methods (EPA, 1999). Pursuant to the technical guidelines for evaluating MNA at petroleum facilities, “hydrocarbon-degrading microorganisms are ubiquitous to the subsurface environment and that these microorganisms can degrade a variety of organic compounds” (Department of Navy, September 1998).

Lines of evidence to define the NA of dissolved COCs would be acquired via a groundwater monitoring program that will use the three-tiered approach (supporting lines of evidence) presented in the EPA's 1999 MNA guidance document (EPA, 1999), as well as methods in other EPA documents (e.g., An Approach for Evaluating the Progress of Natural Attenuation in Groundwater, EPA 600/R-11/204, December 2011). The main line of evidence for NA is the declining and stable COC concentration trends.

In addition to the observed declines of COC concentrations over years of time in site groundwater, certain groundwater conditions also provide evidence that NA is occurring, or that conditions are favorable for NA to degrade dissolved COCs in areas away from remaining source areas. Attainment of drinking water standards in source areas via NA may be difficult to achieve.

DO levels that decrease after passing through areas with hydrocarbon constituents indicates that oxygen is being consumed via aerobic biodegradation. These conditions are reflected in DO concentrations typically less than 1 mg/L and with negative redox values. Under anaerobic conditions (i.e., after DO is sufficiently depleted), nitrate, sulfate, and ferric iron (Fe^{3+}) serve as terminal electron acceptors. Low concentrations of nitrate, sulfate, and ferric iron (Fe^{3+}), and high levels of ferrous iron (Fe^{2+}), indicate that biodegradation is occurring. Alkalinity in the groundwater (caused by carbon dioxide) can also be indicative of the metabolism of microorganisms.

In the groundwater MNA monitoring reports, NA parameter data would be evaluated to determine whether MNA is occurring and is effective at reducing COC concentrations in groundwater. NA parameter data would be compared from impacted and unimpacted wells. Differences in the measured NA parameters from the impacted and unimpacted wells would be reviewed to determine the presence of positive indications that biodegradation and NA of the COCs is occurring. The NA data would also be compared to previous data to determine trends over time.

Results of the fate and transport analysis to assess the credibility of the biodegradation process in site groundwater indicate the biodegradation process is and will continue to reduce the COC distribution and concentrations in site groundwater. These findings are a significant line of evidence for the potential use of an MNA remedy at the site in areas with controlled or depleting source materials.

This alternative also would include institutional controls to eliminate human exposure to affected groundwater in the subsurface, such as prohibiting potable groundwater use via the planned environmental covenant.

5.4 SPL

Below are descriptions of potential corrective measures alternatives specifically evaluated for SPL at the Refinery. Non-hydraulic technologies were not considered because they would likely be ineffective (due to the low vapor pressure and viscosity of the SPL) and impractical for use at an active refinery.

5.4.1 No Action with Institutional Controls

If a TI determination is approved for groundwater in the two TI zones, no additional efforts would be conducted to control, recover, or monitor SPL under this alternative. As part of this alternative, institutional controls would be implemented at the entire Refinery site property to require industrial use only and to eliminate potential human exposure to affected groundwater via the prohibition of potable groundwater use as part of the planned environmental covenant. Other precautions could be implemented to protect workers from subsurface SPL for certain onsite activities.

5.4.2 Manual and Passive SPL Recovery

If SPL recovery is warranted at the facility, this alternative is presented to address the SPL. The removal of SPL from groundwater in a well has been achieved by manual methods and passive skimming devices. Manual SPL recovery involves periodically removing SPL from a well with a bailer or portable pumping equipment, if the water table is relatively shallow (less than 25 feet bgs).

Passive skimming devices use downhole bailers that collect SPL and store a known volume of SPL until the bailer is manually removed and emptied. After the bailer is filled, no additional SPL can be collected. These passive skimming systems are effective when SPL recovery rates are slow or the thickness is small (i.e., less than a few inches). Passive skimming systems would not significantly reduce the source mass and are anticipated to be likely ineffective at controlling SPL migration due to radius of influence relative to well spacing. Previous experience of these types of SPL recovery methods at the Refinery site has proven ineffective. SPL baildown testing completed in 2013 indicates SPL is not recoverable, based on SPL transmissivity results being less than the 0.8 ft^2/day.

5.4.3 Natural Source Zone Depletion

NSZD, as discussed in **Section 2.2.3.5**, is a combination of natural processes that decrease the mass of SPL in the subsurface over time. The rate of NSZD may be greater or more effective than active recovery (i.e. total fluids recovery, skimming recovery, etc.) at decreasing SPL mass (i.e., NSZD will occur with or without hydraulic recovery). Recent literature has reported that NSZD rates range from 300 to 7,700 gallons per acre per year (Garg et. al, 2017) for various petroleum-affected sites. Research studies have identified that NSZD processes can degrade a wide range of hydrocarbons from very light compounds (i.e. in the C4 range) to low volatility/lower solubility compounds (i.e. up to C30 range) (Los Angeles LNAPL Working Group, 2015). Under current site conditions with no contributing sources of SPL, the SPL footprints at the Refinery will decrease in size through NSZD mechanisms with no implemented remedy or other additional action.

6 Evaluation of Corrective Measures Alternatives

Per EPA guidance (EPA, 2011), this section describes each corrective measures alternative that passed through the initial screening and evaluates each corrective measures alternative and its components relative to the following evaluation/balancing criteria: long-term effectiveness; implementability; short-term effectiveness; toxicity, mobility and volume reduction; community acceptance; state acceptance; and cost. Potential corrective measures alternatives for addressing possible unacceptable residential exposure to COCs in soil, groundwater COCs, and SPL, were identified and described in **Section 5**. The objective of the screening and evaluation process is to identify the most suitable alternative for meeting the proposed CAOs and remedial endpoints set forth in **Section 3**, as well as the alternative screening criteria, given the site-specific conditions. The alternatives presented in this section may potentially be used inside and/or outside of the requested TI zones at the refinery to support the short-term and final groundwater goals of the facility. The ICs of the evaluated alternatives would be applied to the entire refinery (inside and outside the TI zones).

Knowledge and experience gained from design, implementation, and operation of previous remediation systems at the Refinery and at similar sites, as well as EPA guidance documents, were used to identify advantages and disadvantages of each alternative. When possible, inherent limitations or limitations caused by facility conditions were identified for each alternative.

Note that institutional controls were not evaluated against the alternative screening criteria, as they will be part of a corrective measure. Utilization of institutional controls will be an important part of certain corrective action alternatives for the site to help meet the CAOs of preventing possible unacceptable residential exposure to COCs in soil, as well as unacceptable exposure to groundwater COCs and SPL. The goal of the corrective measures implemented will be to ensure the CAOs are met (i.e. stable to decreasing groundwater COCs concentrations downgradient of source areas, no offsite migration of dissolved COCs, stable/decreasing SPL footprint, and protection of human health from unacceptable exposure). Further discussion about the final screening results is included in **Section 7**.

6.1 Alternative Screening Criteria

Per the EPA CMS scope of work guidance document (EPA, 2011a), the alternative screening process was used to evaluate the potential corrective action ideas given general and facility-specific conditions, CAOs, and regulatory standards.

Screening criteria included the following:

1. **Long-Term Effectiveness.** Long-term effectiveness refers to the ability of the corrective measures alternative to meet CAOs through effectiveness, reliability, and risk of failure of the alternatives.

2. **Reduction in the Toxicity, Mobility, or Volume of Wastes.** Reduction in

the toxicity, mobility, or volume of wastes refers to the ability of the corrective measures alternative to eliminate or substantially reduce the inherent potential for wastes in the affected media that may cause future environmental releases or other risks to human health and the environment. Comparison between the initial facility conditions and the expected post-corrective measures conditions shall be assessed.

3. **Short-term Effectiveness.** Short-term effectiveness refers to the ability of the corrective measures alternative to meet the CAO for protecting human health and the environment by preventing exposure to the media of concern (i.e. groundwater). This criterion will be satisfied by institutional controls.

4. **Implementability.** Implementability of the corrective measures alternative refers to administrative (permits, off-site approvals) and ease of installation (constructability) feasibility related to facility-specific conditions (i.e., potential land use restrictions and access issues).

5. **Community Acceptance.** Community acceptance refers to the potential to minimize facility/local community disruption and have a positive community reaction if the corrective measures alternative is implemented. Per Ergon, EWVI has been established as the community by EPA. Corrective measures alternatives are is not expected to disrupt Ergon in any way or prevent full use of the facility.

6. **State Acceptance.** State acceptance refers to the corrective measures being acceptable and compliant with the applicable state guidelines and regulations (i.e. West Virginia corrective action practices/procedures and permit requirements).

7. **Cost (Capital, OM&M, and Oversight).** Cost refers to the relative capital, OM&M, and oversight costs of the corrective measures alternative. An approximation of the cost estimates was performed as the focus of this criteria is to make comparative estimates. Estimates are based on prior estimates, site cost experience, and engineering judgment.

6.2 Alternative Screening Results

Results of the screening process for corrective measures alternatives for groundwater and SPL as compared to the above screening criteria are presented in **Tables 6-1** and **6-2**, respectively. The screening evaluation results were used in conjunction with ensuring that the CAOs are achieved and remain successful in the future to determine the eliminated or retained corrective measures alternatives.

Regarding the remedial endpoints of the alternatives, the potential alternatives are evaluated to determine whether they have a likelihood of meeting the endpoint in a reasonable time frame at applicable points of compliance (as warranted). Review of the potential corrective measure alternatives for the dissolved COCs, as presented in **Table 6-1,** indicates that the proposed site-wide CAOs and remedial endpoint of the groundwater should be attained with the No Action with Institutional Controls alternative and the MNA with Institutional Controls alternative, considering the TI determination is approved by the EPA. The known areal extent of the dissolved COCs in site groundwater and the attenuation of the existing dissolved COCs should allow the continued attainment of the CAOs. For SPL, the proposed CAOs and remedial endpoints should be achieved with the two presented alternatives presented in **Table 6-2** (No Action with Institutional Controls and SPL Skimming). Importantly, the two SPL-specific CAOs have already been achieved at the site in which SPL was deemed recovered to the maximum extent practicable based on interim remedial actions, and a stable SPL footprint exists with no impact to receptors.

6.2.1 Eliminated Corrective Measures Alternatives

The following corrective measures alternatives were eliminated based on the screening evaluation results:

<u>Groundwater</u>

- MNA with Institutional Controls – Eliminated, as all short-term groundwater CAOs have been met (achieve stable or declining COC concentrations downgradient of source area and no offsite migration of dissolved COCs) except restoration of groundwater to drinking water standards and protection of human health from unacceptable exposure to affected groundwater. Institutional controls will be implemented for protection of human health from unacceptable exposure. If the TI determination is approved, restoration of groundwater to drinking water standards will not be required within the two TI zones, yet will be outside the TI zone boundaries. This remedy does not provide any additional protection of human health and the environment over the no action alternative.

<u>SPL</u>

- Manual and Passive SPL Skimming – Eliminated, as SPL is not migrating and has been historically recovered to the maximum extent practicable**.** Additionally, previous results indicate that manual and passive recovery would be ineffective at supporting footprint stability.

6.2.2 Retained Corrective Alternatives Measures

The retained corrective measures alternatives based on the screening evaluation for soil, groundwater, and SPL are No Action with Institutional Controls. The alternatives are discussed further in **Section 7**. The dissolved COCs in groundwater do not pose an unacceptable risk to receptors with established institutional controls. If a TI determination is approved by the EPA, existing NA processes will continue to decrease the concentrations and extent of the affected groundwater area in the central part of the Refinery where it exists. The No Action alternative for SPL is warranted based on the existing SPL data. The No Action alternatives are the most cost-effective alternatives and require no additional infrastructure for implementation. Active remedies for groundwater and SPL do not provide any additional protectiveness of human health and the environment once ICs are instituted and implemented.

Table 6-1
Corrective Measures Alternatives Screening Summary - Soil

Evaluation Criteria	Corrective Measures Alternatives
	Institutional Controls
1. Long-Term Effectiveness	Effective at long-term protection of human health and the environment.
2. Reduction of Toxicity, Mobility, and Mass	No active remedy is necessary and will prevent unacceptable residential exposure soil COCs.
3. Short-Term Effectiveness	Effective for preventing unacceptable residential exposure soil COCs.
4. Implementability	Implementable with no equipment or infrastructure needed
5. Community Acceptance	EWVI has been established as the community by EPA. No community disruption with its implementation. Community acceptance expected to be positive.
6. State Acceptance	Institutional controls are an accepted remedy by the WVDEP.
7. Cost	Overall: None

Acronyms and Abbreviations:

DEP = Department of Environmental Protection

Table 6-2
Corrective Measures Alternatives Screening Summary - Groundwater

Evaluation Criteria	Corrective Measures Alternatives	
	No Action with Institutional Controls	**Monitored Natural Attenuation with Institutional Controls**
1. Long-Term Effectiveness	Existing natural attention (NA) will reduce the mass and extent of dissolved COCs in the subsurface. NA is occuring based on existing groundwater data from the Refinery. Minimal risk of failure without further COC source contribution.	Will ensure groundwater COC concentrations remain stable or decreasing in the long term. MNA is reliable based on existing groundwater data from the Refinery. Minimal risk of failure without further COC source contribution.
2. Reduction of Toxicity, Mobility, and Mass	Although not measured, NA will reduce the mass and mobility of dissolved COCs and thus reduce its toxicity in the subsurface.	NA will reduce the mass and mobility of dissolved COCs and thus reduce its toxicity in the subsurface.
3. Short-Term Effectiveness	Short-term effectiveness for preventing unacceptable exposure of groundwater COCs achieved with institutional controls and an environmental covenant preventing potable use of groundwater.	
4. Implementability	Implementable with no equipment or infrastructure needed	Implementable with no additional infrastructure needed
5. Community Acceptance	EWVI has been established as the community by EPA. No community disruption with its implementation. Community acceptance expected to be positive.	
6. State Acceptance	Could be an acceptable method. WVDEP permits are not required.	MNA is an acceptable method to address groundwater at suitable sites with the EPA. WVDEP permits are not required.
7. Cost	Overall: None	Total: approx. $40,000USD for MNA monitoring (one sampling/monitoring event and one report annually)
		Capital: None to Low
		OM&M: Low

Acronyms and Abbreviations:

DEP = Department of Environmental Protection

MNA = monitored natural attenuation

Table 6-3
Corrective Measures Alternatives Screening Summary - SPL

Evaluation Criteria	Corrective Measures Alternatives	
	No Action with Institutional Controls	**SPL Skimming**
1. Long-Term Effectiveness	Considered effective for achieving established CAOs for SPL because natural processes continue to deplete mass from the stable SPL footprint. Additionally, the SPL footprint of the closest area of SPL is located approximately 200 feet from the site boundary.	Not effective. SPL has been recovered to the maximum extent practicable.
2. Reduction of Toxicity, Mobility, and Mass	SPL is stable (not migrating). Overall SPL mass will decrease over time through natural processes.	Not effective. SPL has been recovered to the maximum extent practicable; therefore toxicity, mobility, and mass would not be reduced with SPL skimming.
3. Short-Term Effectiveness	Short-term effectiveness for preventing unacceptable exposure of SPL achieved with institutional controls and an environmental covenant preventing potable use of groundwater.	
4. Implementability	Implementable with no equipment or infrastructure needed	Implementable with no additional infrastructure needed
5. Community Acceptance	EWVI has been established as the community by EPA. No community disruption with its implementation. Community acceptance expected to be positive.	
6. State Acceptance	No further action is an acceptable method to address SPL at suitable sites with WVDEP. WVDEP permits are not required.	SPL skimming is an acceptable method to address SPL at suitable sites with WVDEP. WVDEP permits are not required.
7. Cost	Overall: None	Total: Medium (approx. $275,000USD)
		Capital: Medium (approx. $35,000USD) - 5 skimmer pumps and related equipment and installation
		OM&M: Medium (approx. $240,000) - 5 years

Acronyms and Abbreviations:
DEP = Department of Environmental Protection
SPL = separate phase liquid

7 Selection of the Corrective Measures Alternatives

The purpose of the CMS is to identify and evaluate potential corrective measures alternatives that address affected media (soil, groundwater, and SPL) at the Refinery and to select a combination of final corrective measures alternatives that, once implemented, will achieve CAOs per the RCRA process.

Implementation of institutional controls via an environment covenant is recommended to ensure no unacceptable exposure to COCs in site media is possible at the Refinery and to achieve the CAOs.

The CAOs for groundwater of achieving stable to decreasing COC concentrations downgradient of source areas and no off-site migration of dissolved COCs in site groundwater have been met.

The CAOs for SPL (demonstrating a stable SPL footprint and recovery of SPL to maximum extent practicable) have been achieved. SPL mass and footprint will decrease as NSZD processes continue to deplete the SPL mass.

7.1 Institutional Controls

Institutional controls shall be implemented at the complete Refinery property as part of the final remedy to protect potential receptors from subsurface impacts, thereby eliminating possible unacceptable exposure pathways from site media to humans. Future use and development at the Refinery will be restricted to industrial/commercial purposes. As long as Ergon West Virginia, Inc. (EWVI) operates the refinery, it will maintain responsibility of all on-site areas indefinitely and will manage and control intrusive work to protect its workers. Other possible institutional controls, such as health and safety protocols and affected subsurface material management, may also be used to mitigate risk and prevent exposure to site workers.

Because the future use of the site will be for industrial purposes, precautions will be implemented by Ergon and other tenants on the Refinery to prevent human receptors from coming into contact with the certain materials in the subsurface of identified areas at the Refinery. The following precautions should be implemented:

- The Refinery will maintain a secured entrance at all times through use of fences and gates.
- All excavations within 2 feet of anticipated groundwater table in areas of known SPL and in the MEK Dewaxing area (presence of MEK and toluene) will be managed by EWVI to protect workers conducting soil excavation activities.

Details of the institutional controls implementation will be included in the institutional controls plan as part of the Corrective Measures Implementation Plan.

The site-specific institutional controls will be included in the land use/environmental covenant that will be submitted and recorded for the Refinery. The environmental covenant will allow groundwater to be used for industrial purposes only and prohibit the potable use of groundwater.

The unacceptable potential risk to hypothetical future adult and child residents for the potable use of site groundwater and exposure to COCs in soil will be addressed via land use limitations and activity restrictions per a land use/environmental covenant placed on the subject property. The environmental covenant will be executed pursuant to the Uniform Environmental Covenants Act (W. Va. Code § 22-22B) and follow guidance from the WVDEP "Land Use Covenant Instructions" (WVDEP, 2019). This covenant, which will be approved by EPA and WVDEP, will be finalized after EPA approval of this CMS and the Final Decision document and will be recorded with the local county.

The environmental covenant will include the following two site activity and use limitations:

1. The property will be used for industrial (non-residential) purposes only.

2. No use of groundwater for potable purposes (including drinking water and routine personal showering/washing). Groundwater at the subject property can be used for industrial and other purposes.

The environmental covenant will make the soil and groundwater exposure pathways incomplete for the future adult and child resident. A draft environmental covenant was prepared with collaborated with the site operator, EWVI, and was submitted to the EPA for review on April 23, 2019.

7.2 No Action with Institutional Controls for Soil

No Action with institutional controls is the recommended alternative for satisfying the soil CAO that the COCs do not pose a potential unacceptable risk to a future resident.

The HHRA (AECOM, 2017) determined exposure to site soil did not cause an unacceptable risk (unacceptable is defined as TR greater than 1×10^{-4} and Target HI greater than 1.0) to current and future industrial site workers and ecological receptors; therefore, remedial action to address soil is not warranted. A land use limitation of the EC will prohibit any future residential use of the site by limiting the site to industrial use only.

7.3 No Action with Institutional Controls for Groundwater

No Action with institutional controls is the recommended alternative for satisfying the groundwater CAOs, considering the TI determination for groundwater in the TI zones is approved by the EPA. Institutional controls (as discussed in **Section 7.1**) to eliminate human exposure to affected groundwater in the subsurface as part of an environmental covenant will meet the groundwater CAO of protection of human health from unacceptable exposure to dissolved-phase COCs in groundwater.

Site data demonstrate that biodegradation through NA of dissolved-phase hydrocarbon constituents is occurring at the Refinery, as described in **Section 2.2.2.4**. The mechanisms of NA will continue to reduce the affected groundwater and its COC concentrations in the MEK

Dewaxing Area and North of the MEK Dewaxing Area in areas with no active nearby source without the need for an active remedy.

7.4 No Action with Institutional Controls for SPL

If the TI determination is approved by the EPA, No Action with Institutional Controls is the recommended alternative for satisfying the SPL CAOs for SPL footprint stability and SPL recovery to the extent practicable in the following areas: MEK Dewaxing Area, North of the MEK Dewaxing Area, LBA, and isolated SPL accumulations. SPL at the site has been recovered to the maximum extent practicable, and a stable SPL footprint has been achieved. Additionally, as described in **Section 2.2.3.5**, soil gas data at the site indicate that NSZD processes are depleting the SPL mass. No current or future receptors will be exposed to SPL in groundwater. The environmental covenant restricting potable use of groundwater will prevent unacceptable exposure to SPL in groundwater. The depth of SPL in the subsurface is below the depth where common excavation activities might occur (SPL at or below 12 feet bgs).

7.5 Remedial Endpoints

For soil, the proposed remedial endpoint is attainment of the soil CAOs. For the dissolved COCs in site groundwater, the proposed remedial endpoint is achievement of the groundwater CAOs. For SPL, the proposed remedial endpoint is attainment of the SPL CAOs.

8 CMS Reporting Process

A draft and final CMS Report will be prepared presenting the results of Tasks I through III of the EPA CMS scope of work guidance document (EPA, 2011a) and recommending corrective measures alternatives for the subject Refinery to address the current environmental conditions. This Draft CMS Report satisfies this requirement. If required by the EPA, a modification of Draft CMS to a Final CMS Report will also be prepared.

Progress reports will continue to be prepared and will be submitted bi-annually (twice a year) during the CMS process (until this Final CMS Report is approved by the EPA). They will include:

1. A description and estimate of the percentage of the CMS completed;

2. Summaries of all findings;

3. Summaries of all changes made in the CMS during the reporting period;

4. Summaries of all contacts with representatives of the local community, public interest groups, or state government during the reporting period;

5. Summaries of all problems or potential problems encountered during the reporting period;

6. Actions being taken to rectify problems;

7. Changes in personnel during the reporting period;

8. Projected work for the next reporting period; and

9. Copies of daily reports, inspection reports, laboratory/monitoring data, etc.

Submission Summary

The CMS report will be submitted in accordance to the following timeline:

Facility Submission	Due Date
Draft CMS Report	Sixty (60) calendar days after receipt of EPA approval of the Final RFI.
Final CMS Report	Thirty (30) calendar days after EPA comment on the Draft CMS.
Modification of Final CMS Report (if required by EPA)	Thirty (30) calendar days after the 21-day public comment period on the Final CMS Report.
Progress Reports	Submitted bi-annually in January and July (for 6-month periods).

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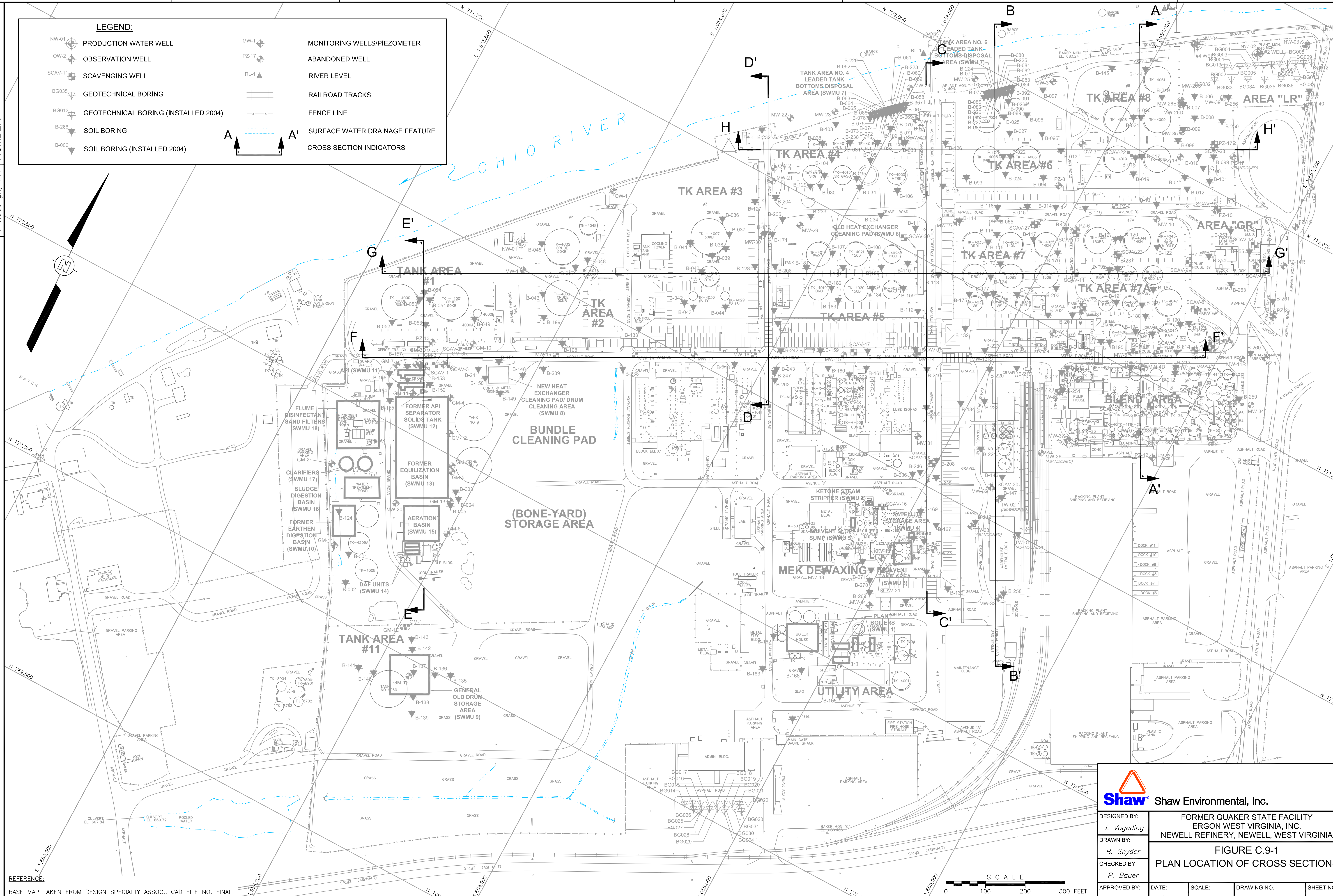
Appendix A

Geologic Cross Sections



LEGEND:

NW-01	PRODUCTION WATER WELL	MW-1	MONITORING WELLS/PIEZOMETER
OW-2	OBSERVATION WELL	PZ-17	ABANDONED WELL
SCAV-11	SCAVENGING WELL	RL-1	RIVER LEVEL
BG035	GEOTECHNICAL BORING		RAILROAD TRACKS
BG013	GEOTECHNICAL BORING (INSTALLED 2004)		FENCE LINE
B-266	SOIL BORING		SURFACE WATER DRAINAGE FEATURE
B-006	SOIL BORING (INSTALLED 2004)	A A'	CROSS SECTION INDICATORS

REFERENCE:
BASE MAP TAKEN FROM DESIGN SPECIALTY ASSOC., CAD FILE NO. FINAL BORING LOCATION DRAWING OF 08-03-04.DWG.

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Plotted by: arthur.smith

Xref: 812892X3
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OFFICE: Pittsburgh, PA
DRAWING NUMBER: 812892-D118

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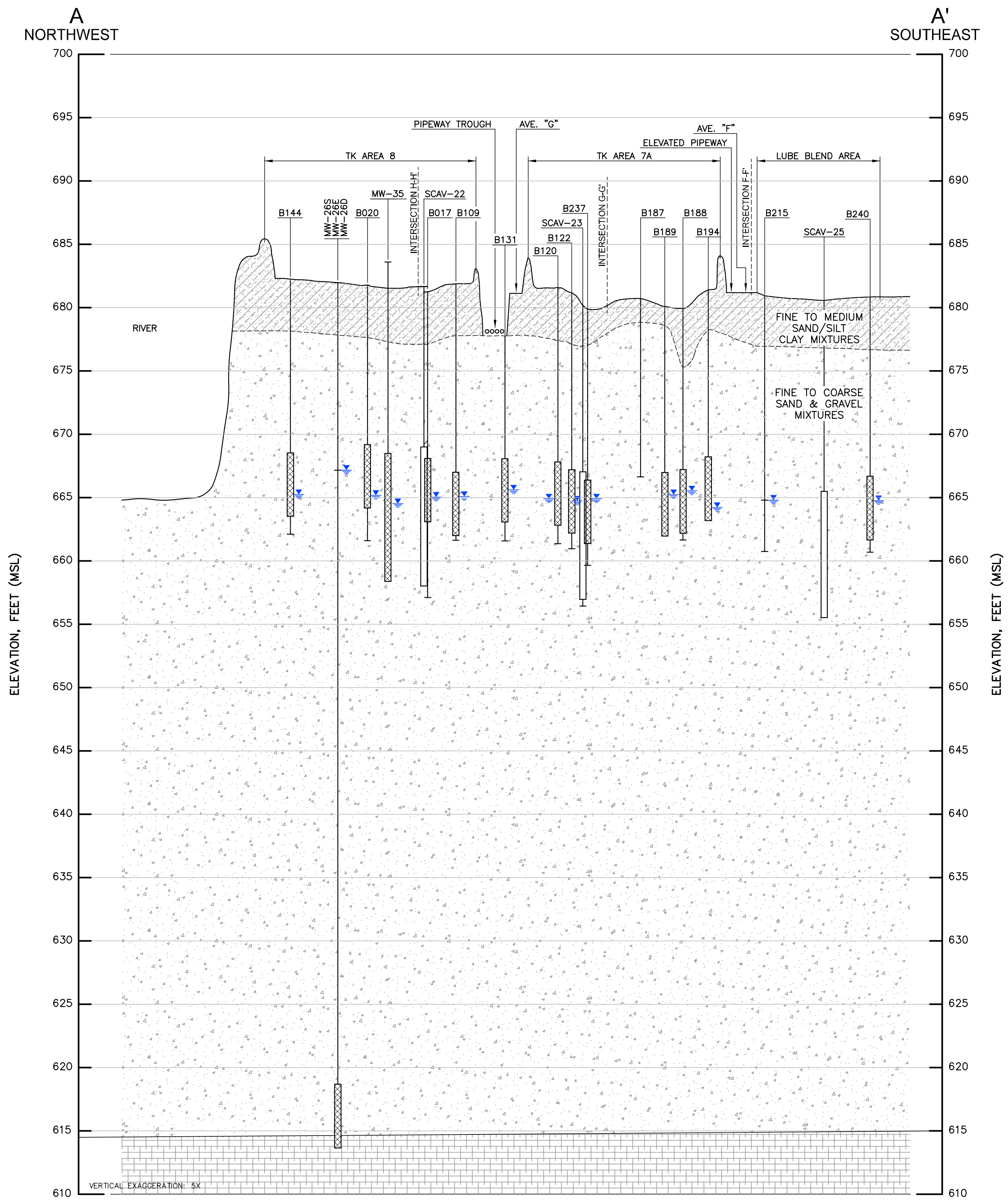
ERGON WEST VIRGINIA, INC.
NEWELL REFINERY, NEWELL, WEST VIRGINIA

FIGURE C.9-1
PLAN LOCATION OF CROSS SECTIONS

DESIGNED BY:	DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:	SCALE:	DRAWING NO.	SHEET NO.
J. Vogeding	B. Snyder	P. Bauer	S. Tituskin	10/23/06	AS SHOWN	812892-D118	--

Point	Projection (feet)	(direction)
B144	10	west
B020	2	west
B017	5	west
B019	18	east
B120	48	east
B122	40	west
B237	50	east
B187	31	west
B189	5	west
B188	15	west
B194	5	east
B215	20	east
B240	2	east
MW-26	100	west
MW-35	100	west
SCAV-22	22	east
SCAV-23	50	east
SCAV-25	30	west



SECTION A-A'
LOOKING NORTHEAST

LEGEND:

- STATIC GROUNDWATER LEVEL MEASURED ON OCTOBER 17, 2002
- SCREEN INTERVAL
- INFERRED
- BOTTOM OF BOREHOLE
- FINE TO MEDIUM SAND/SILT CLAY MIXTURES
- FINE TO COARSE SAND & GRAVEL MIXTURES
- SHALE BEDROCK

VERTICAL SCALE 0 5 10 15 FEET

HORIZONTAL SCALE 0 100 200 300 FEET

Shaw™ Shaw Environmental, Inc.

DESIGNED BY: J. Vogeding	FORMER QUAKER STATE FACILITY ERGON WEST VIRGINIA, INC. NEWELL REFINERY, NEWELL, WEST VIRGINIA
DRAWN BY: B. Snyder	FIGURE C.9-2 GENERALIZED GEOLOGIC CROSS SECTION A-A'
CHECKED BY: P. Bauer	
APPROVED BY: S. Tituskin	DATE: 8/24/06 · SCALE: AS SHOWN · DRAWING NO. 812892-D108 · SHEET NO. --

OFFICE Pittsburgh, PA
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Plotted by: arthur.smith

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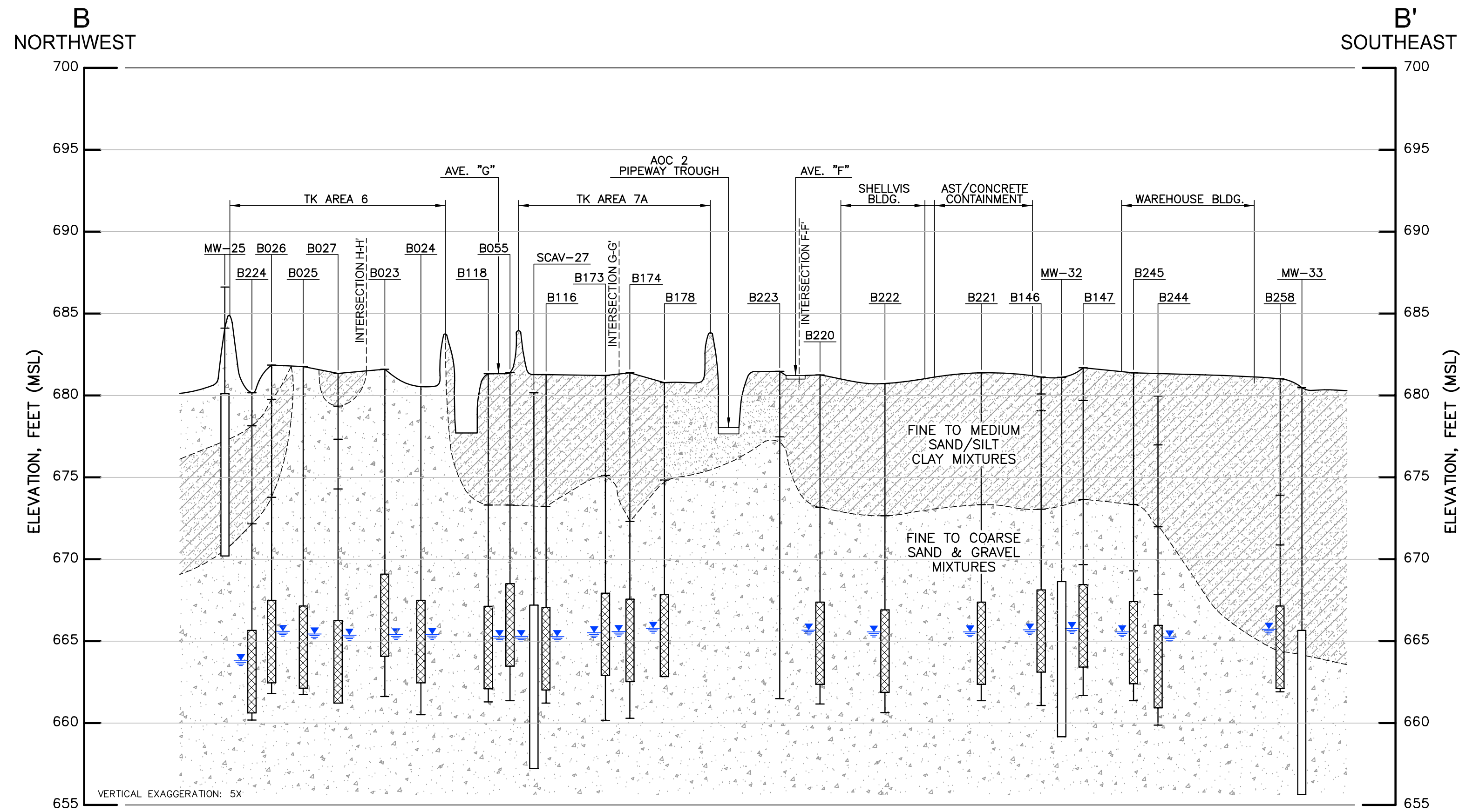
B224	5	east
B026	30	west
B025	20	west
B027	35	west
B023	18	west
B024	22	west
B118	2	west
B055	1	west
B116	2	west
B173	9	west
B174	12	east
B178	5	east
B223	29	east
B220	17	east
B222	30	east
B221	37	east
B146	12	west
B147	11	west
B245	51	east
B244	52	west
B258	15	west
MW-25	52	east
SCAV-27	90	west
MW-32	15	east
MW-33	8	west



SECTION B-B'
LOOKING NORTHEAST

LEGEND:

- STATIC GROUNDWATER LEVEL MEASURED ON OCTOBER 17, 2002
- SCREEN INTERVAL
- INFERRED
- BOTTOM OF BOREHOLE
- FINE TO MEDIUM SAND/SILT CLAY MIXTURES
- FINE TO COARSE SAND & GRAVEL MIXTURES

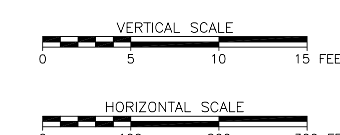


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FIGURE C.9-3
GENERALIZED GEOLOGIC
CROSS SECTION B-B'

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OFFICE Pittsburgh, PA
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Plotted by: william.snyder

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B126	39	west
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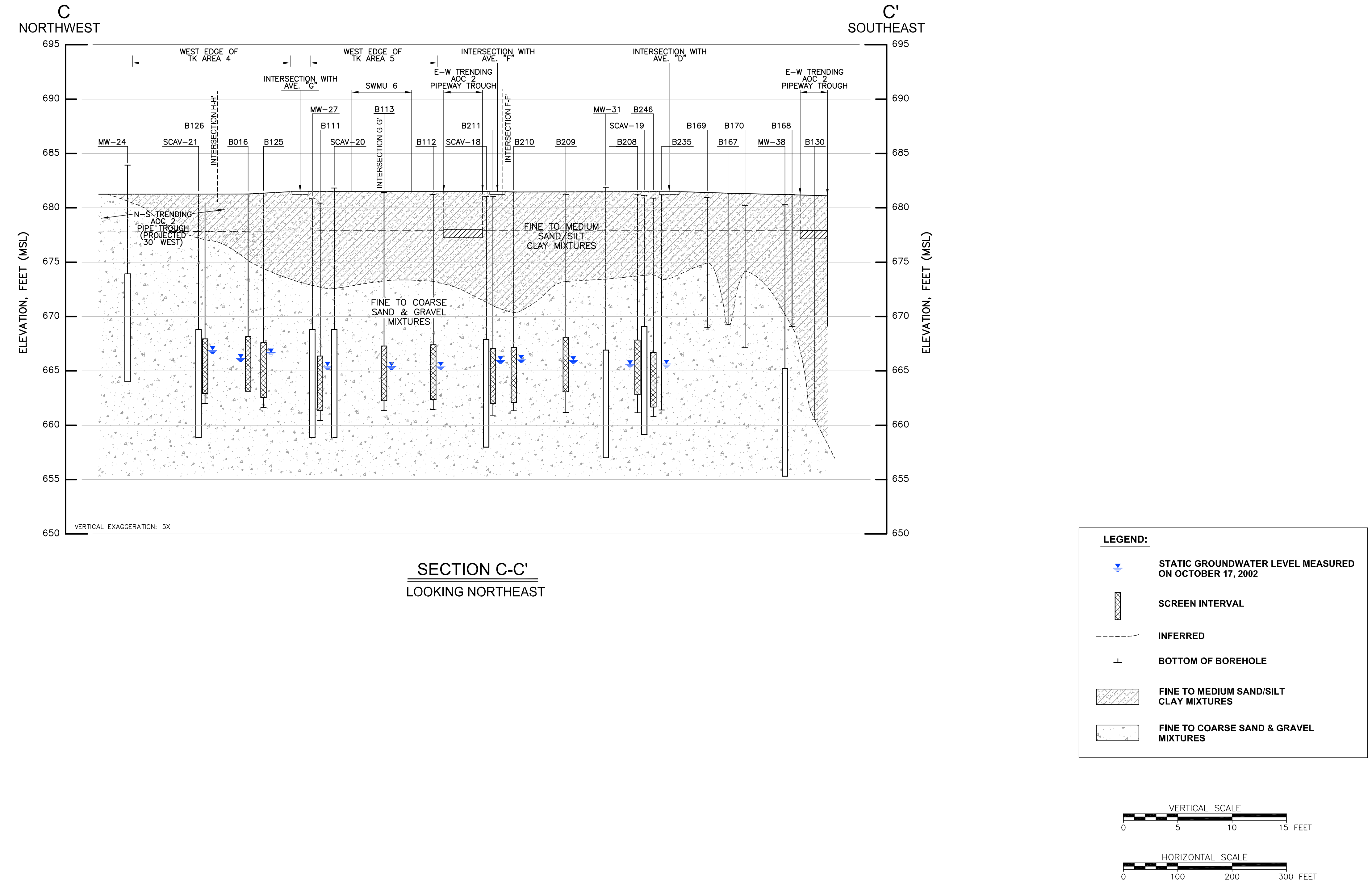
B125	35	west
B111	33	east
B113	22	west
B112	25	east
B211	30	east
B210	2	east
B209	2	east
B208	21	west
B246	20	east
B235	20	west
B169	18	west
B167	20	west
B170	33	east
B168	1	east
B130	52	west
MW-24	42	east
SCAV-21	65	east
MW-27	70	west
SCAV-20	55	east
SCAV-18	20	east
MW-31	20	east
SCAV-19	10	west
MW-38	105	east



SECTION C-C'

LOOKING NORTHEAST

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ERGON WEST VIRGINIA, INC.
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FIGURE C.9-4
GENERALIZED GEOLOGIC
CROSS SECTION C-C'

DESIGNED BY:	DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:	SCALE:	DRAWING NO.	SHEET NO.
J. Vogeding	B. Snyder	P. Bauer	S. Tituskin	8/30/06	AS SHOWN	812892-D109	--

OFFICE: Pittsburgh, PA
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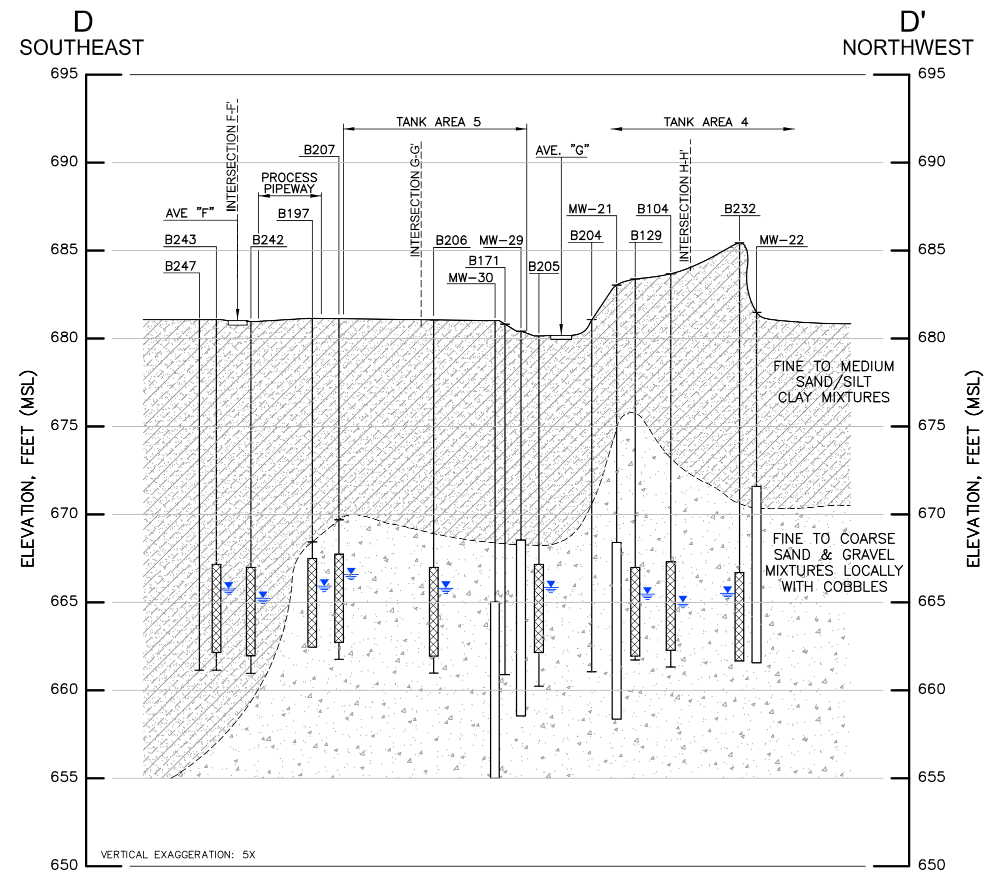
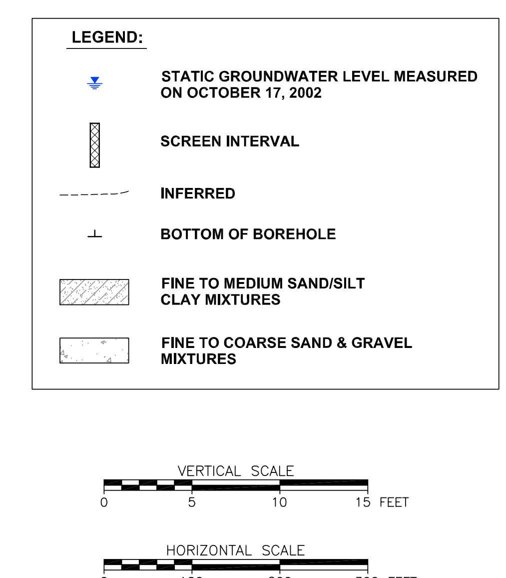
Plotted by: william.snyder

Point	Projection (feet)	Projection (direction)
B247	30	west
B243	35	west
B242	52	west
B197	45	west
B207	20	west
B206	20	west
B171	25	west
B205	62	west
B204	30	west
B232	35	east
MW-30	15	east
MW-29	76	west
MW-21	10	west
MW-22	55	west



SECTION D-D'
LOOKING SOUTHWEST



Shaw Environmental, Inc.

DESIGNED BY: J. Vogeding	FORMER QUAKER STATE FACILITY ERGON WEST VIRGINIA, INC. NEWELL REFINERY, NEWELL, WEST VIRGINIA
DRAWN BY: B. Snyder	FIGURE C.9-5 GENERALIZED GEOLOGIC CROSS SECTION D-D'
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APPROVED BY: S. Tituskin	DATE: 8/30/06 · SCALE: AS SHOWN · DRAWING NO. 812892-D114 · SHEET NO. --

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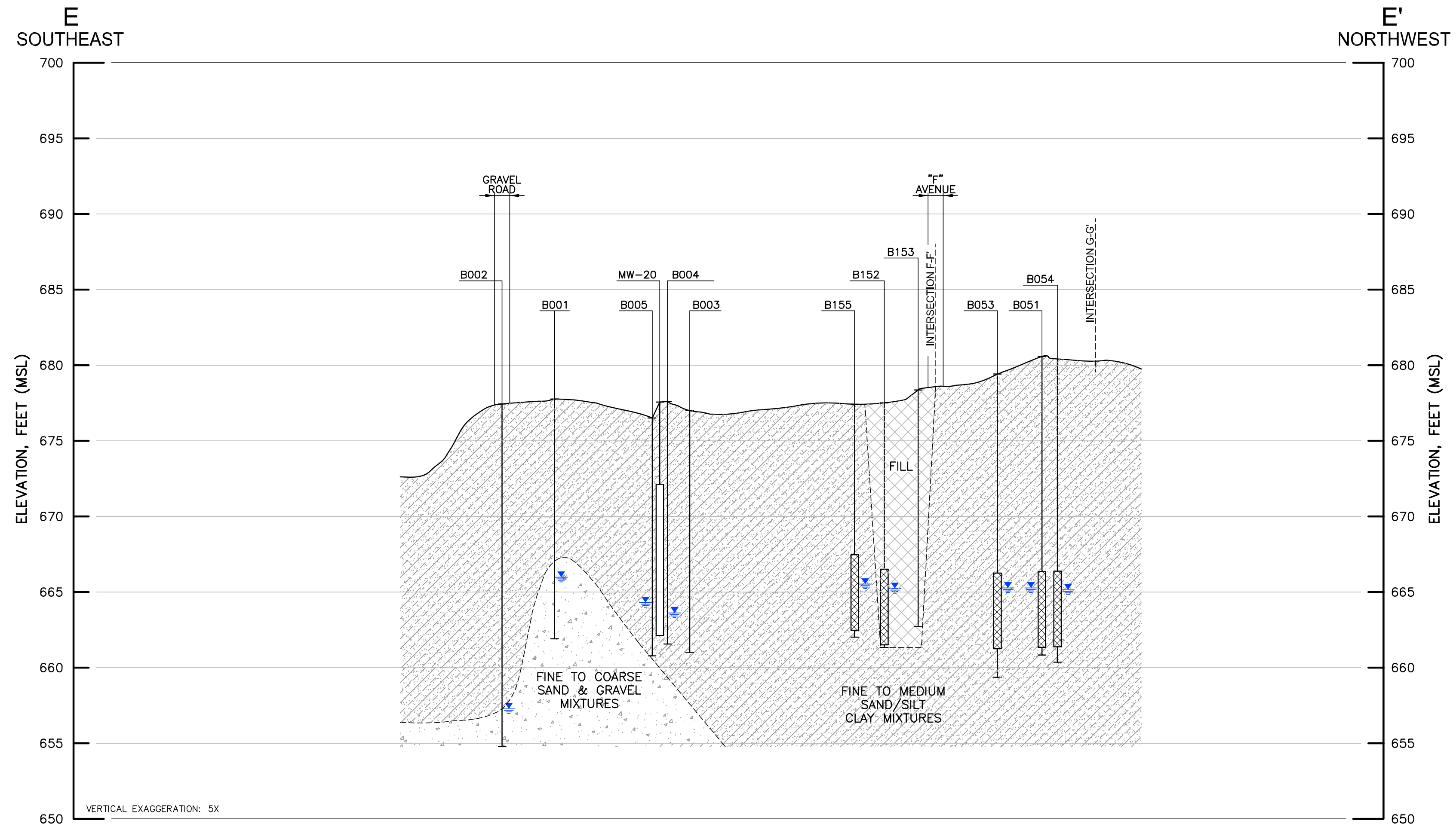
Plotted by: william.snyder

Point	Projection (feet)	(direction)
B002	200	east
B001	190	east
B005	62	west
B004	85	west
B003	75	west
B155	90	east
B152	10	west
B153	8	east
B053	2	west
B051	10	west
B054	2	west
MW-20	74	east



SECTION E-E'
LOOKING SOUTHWEST

LEGEND:

- STATIC GROUNDWATER LEVEL MEASURED ON OCTOBER 17, 2002
- SCREEN INTERVAL
- INFERRED
- BOTTOM OF BOREHOLE
- FINE TO MEDIUM SAND/SILT CLAY MIXTURES
- FINE TO COARSE SAND & GRAVEL MIXTURES

VERTICAL SCALE 0 5 10 15 FEET

HORIZONTAL SCALE 0 100 200 300 FEET

Shaw Environmental, Inc.

DESIGNED BY: J. Vogeding	FORMER QUAKER STATE FACILITY ERGON WEST VIRGINIA, INC. NEWELL REFINERY, NEWELL, WEST VIRGINIA
DRAWN BY: B. Snyder	FIGURE C.9-6 GENERALIZED GEOLOGIC CROSS SECTION E-E'
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APPROVED BY: S. Tituskin	DATE: 8/30/06 · SCALE: AS SHOWN · DRAWING NO. 812892-D112 · SHEET NO. --

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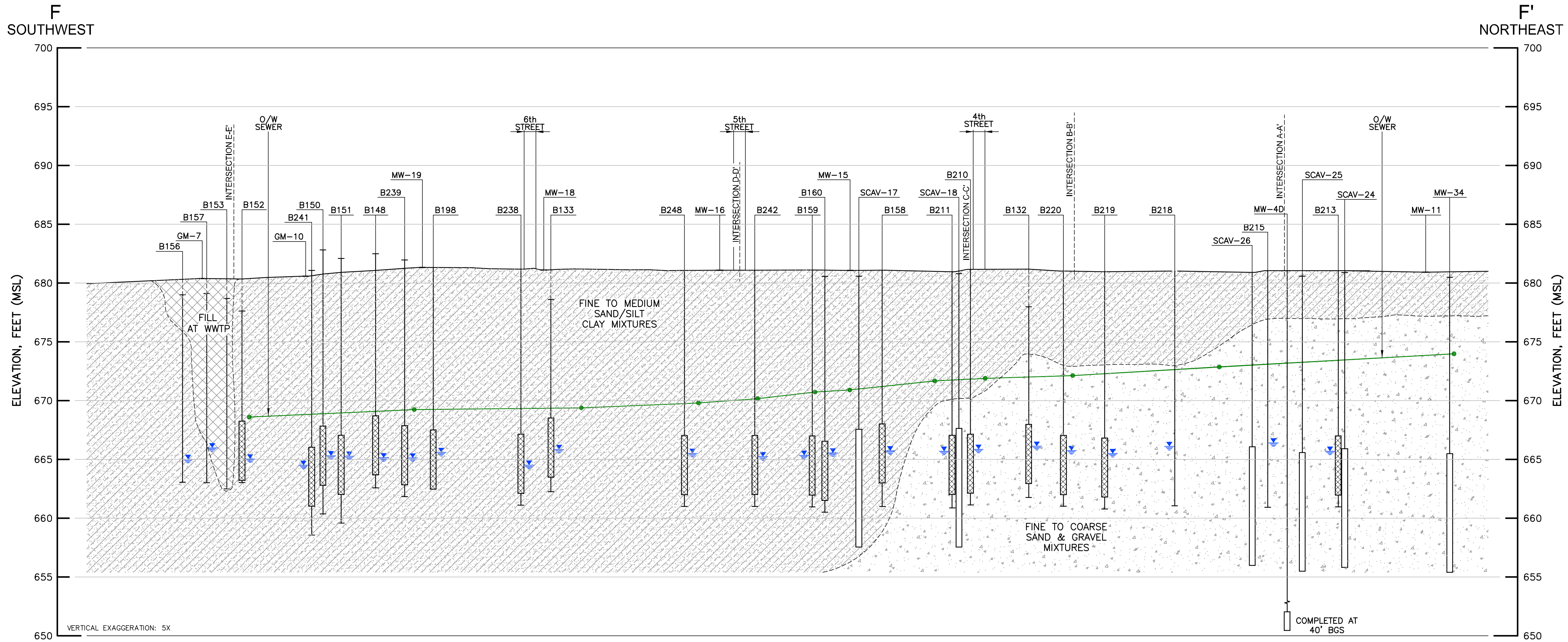
B153	21	north
B152	68	north
B241	38	north
B150	50	north
B151	10	north
B148	45	north
B239	38	north
B198	32	south
B238	30	north
B133	70	south
B248	19	north
B242	15	south
B159	15	south
B160	28	north
B158	12	south
B211	2	south
B210	32	north
B132	70	south
B220	30	north
B219	29	north
B218	10	south
B215	25	north
B213	25	north
SCAV-17	10	south
SCAV-18	10	south
SCAV-26	116	north
MW-4D	25	north
SCAV-25	125	north
SCAV-24	90	north
MW-34	120	north



SECTION F-F'

LOOKING NORTHWEST

LEGEND:

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- SCREEN INTERVAL
- INFERRED
- BOTTOM OF BOREHOLE
- O/W (OILY WATER/SEWER)
- FINE TO MEDIUM SAND/SILT CLAY MIXTURES
- FINE TO COARSE SAND & GRAVEL MIXTURES

VERTICAL SCALE: 0 5 10 15 FEET

HORIZONTAL SCALE: 0 100 200 300 FEET

Shaw Environmental, Inc.

DESIGNED BY: J. Vogeding	FORMER QUAKER STATE FACILITY ERGON WEST VIRGINIA, INC. NEWELL REFINERY, NEWELL, WEST VIRGINIA		
DRAWN BY: B. Snyder	FIGURE C.9-7 GENERALIZED GEOLOGIC CROSS SECTION F-F'		
CHECKED BY: P. Bauer			
APPROVED BY: S. Tituskin	DATE: 8/30/06	SCALE: AS SHOWN	DRAWING NO. 812892-D110 / SHEET NO. --

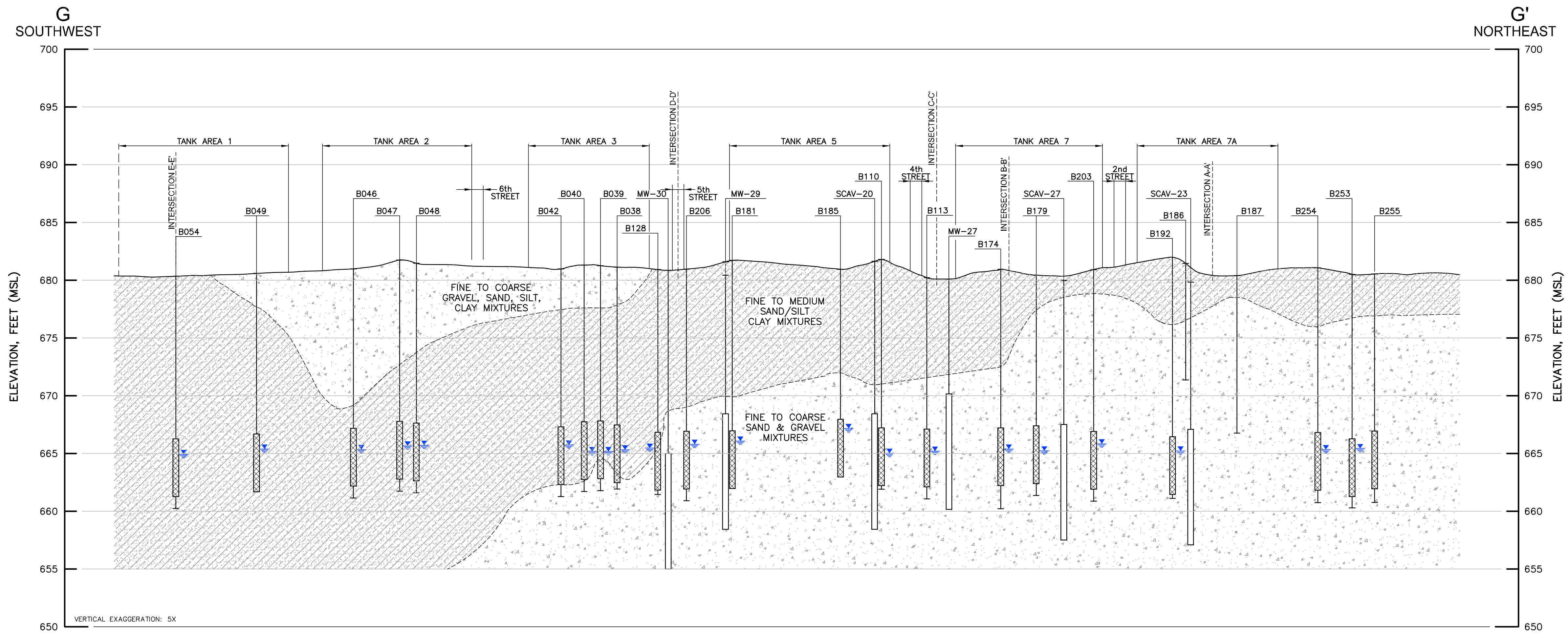
OFFICE: Pittsburgh, PA
DRAWING NUMBER: 812892-D110

VERIFY SCALE 0 1"

Xref: .
Image: scanX-X

O:\Project\812892\812892D110.dwg
Plot Date/Time: 01/29/07 03:09pm
Plotted by: william.snyder

Point	Projection (feet)	Projection (direction)
B054	40	north
B049	110	north
B046	50	north
B047	15	south
B048	30	south
B042	70	north
B040	3	south
B039	45	south
B038	60	south
B128	17	south
B206	17	south
B181	15	south
B185	12	south
B110	22	south
B113	1	north
B174	5	north
B179	50	north
B203	35	north
B192	10	south
B186	13	south
B187	38	north
B254	42	south
B253	25	north
B255	52	south
MW-30	90	south
MW-29	118	south
SCAV-20	90	south
MW-27	125	south
SCAV-27	120	south
SCAV-23	45	south



SECTION G-G'
LOOKING NORTHWEST

LEGEND:

- STATIC GROUNDWATER LEVEL MEASURED ON OCTOBER 17, 2002
- SCREEN INTERVAL
- INFERRED
- BOTTOM OF BOREHOLE
- FINE TO MEDIUM SAND/SILT CLAY MIXTURES
- FINE TO COARSE SAND & GRAVEL MIXTURES

VERTICAL SCALE: 0 5 10 15 FEET

HORIZONTAL SCALE: 0 100 200 300 FEET

Shaw™ Shaw Environmental, Inc.

DESIGNED BY: J. Vogeding
DRAWN BY: B. Snyder
CHECKED BY: P. Bauer
APPROVED BY: S. Tituskin

FORMER QUAKER STATE FACILITY
ERGON WEST VIRGINIA, INC.
NEWELL REFINERY, NEWELL, WEST VIRGINIA

FIGURE C.9-8
GENERALIZED GEOLOGIC
CROSS SECTION G-G'

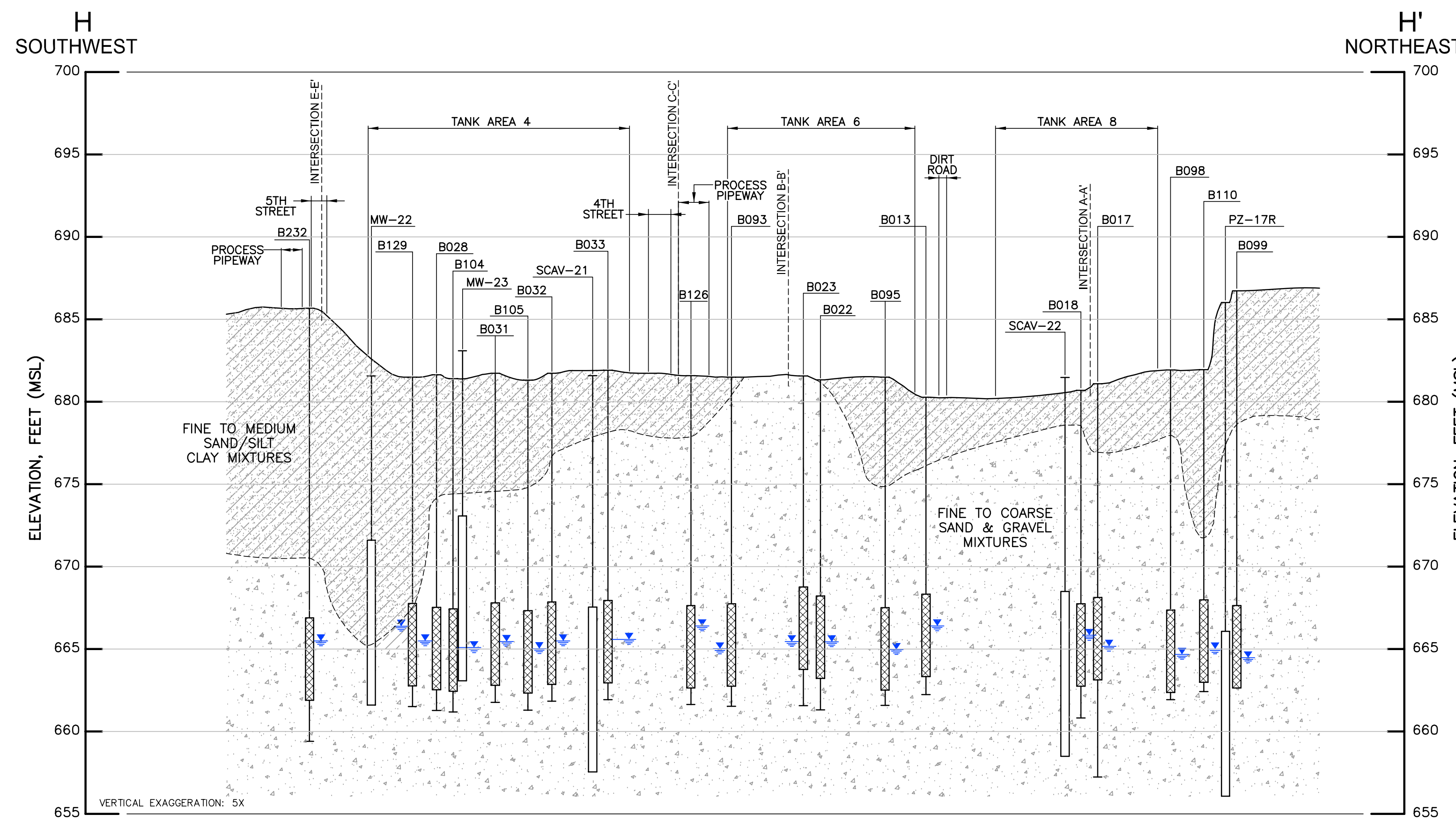
DATE:	SCALE:	DRAWING NO.	SHEET NO.
8/30/06	AS SHOWN	812892-D111	--

OFFICE: Pittsburgh, PA
DRAWING NUMBER: 812892-D111

VERIFY SCALE 0 1"

Xref: .
Image: .

O:\Project\812892\812892D111.dwg
Plot Date/Time: 01/29/07 03:12pm
Plotted by: william.snyder



SECTION H-H'
LOOKING NORTHWEST

Point	Projection (feet)	Projection (direction)
B232	50	south
B129	86	north
B028	20	south
B104	20	north
B031	21	south
B105	22	north
B032	19	south
B033	20	south
B126	18	south
B093	65	north
B023	15	north
B022	13	north
B095	40	south
B013	1	north
B018	18	north
B017	12	north
B098	22	south
B110	13	north
B099	15	north
MW-22	78	south
MW-23	90	south
SCAV-21	19	south
SCAV-22	10	north
PZ-17R	8	south

LEGEND:

- STATIC GROUNDWATER LEVEL MEASURED ON OCTOBER 17, 2002
- SCREEN INTERVAL
- INFERRED
- BOTTOM OF BOREHOLE
- FINE TO MEDIUM SAND/SILT CLAY MIXTURES
- FINE TO COARSE SAND & GRAVEL MIXTURES

VERTICAL SCALE 0 5 10 15 FEET

HORIZONTAL SCALE 0 100 200 300 FEET

Shaw Environmental, Inc.

FORMER QUAKER STATE FACILITY
ERGON WEST VIRGINIA, INC.
NEWELL REFINERY, NEWELL, WEST VIRGINIA

FIGURE C.9-9
GENERALIZED GEOLOGIC
CROSS SECTION H-H'

DESIGNED BY:	DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:	SCALE:	DRAWING NO.	SHEET NO.
J. Vogeding	B. Snyder	P. Bauer	S. Tituskin	9/18/06	AS SHOWN	812892-D115	--

OFFICE Pittsburgh, PA
DRAWING NUMBER 812892-D115

VERIFY SCALE 0 1"

Xref: .
Image: scanZ-Z

O:\Project\812892\812892D115.dwg
Plot Date/Time: 01/29/07 03:14pm
Plotted by: william.snyder

Appendix B

Data Tables

Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
GM-1 [32.29, 12.29-31.99]							
	11/13/2012	ND	16.48	35.61	ND	664.68	664.68
	02/18/2013	ND	16.47	35.63	ND	664.69	664.69
	05/20/2013	ND	16.29	35.63	ND	664.87	664.87
	08/19/2013	ND	16.32	35.63	ND	664.84	664.84
	11/04/2013	ND	16.19	35.61	ND	664.97	664.97
	03/10/2014	ND	16.64	35.61	ND	664.52	664.52
	05/19/2014	ND	15.23	35.61	ND	665.93	665.93
	06/01/2015	ND	16.15	35.61	ND	665.01	665.01
	05/31/2016	ND	16.24	36.01	ND	664.92	664.92
	06/05/2017	ND	16.38	36.01	ND	664.78	664.78
	06/04/2018	ND	16.17	36.01	ND	664.99	664.99
GM-1D [47.28, 37.28-46.98]							
	11/13/2012	ND	16.59	51.00	ND	664.67	664.67
	02/18/2013	ND	14.58	51.00	ND	666.68	666.68
	05/20/2013	ND	16.39	51.00	ND	664.87	664.87
	08/19/2013	ND	16.44	51.00	ND	664.82	664.82
	11/04/2013	ND	16.32	50.98	ND	664.94	664.94
	03/10/2014	ND	16.77	50.98	ND	664.49	664.49
	05/19/2014	ND	15.38	50.98	ND	665.88	665.88
	06/01/2015	ND	16.28	50.98	ND	664.98	664.98
	05/31/2016	Well Not Gauged - PVC Well Casing Damaged					
	06/05/2017	ND	16.56	51.05	ND	664.70	664.70
	06/04/2018	ND	16.43	51.05	ND	664.83	664.83
GM-2 [26.816, 6.816-26.516]							
	11/13/2012	ND	14.80	28.05	ND	664.25	664.25
	02/18/2013	ND	14.84	28.13	ND	664.21	664.21
	05/20/2013	ND	14.61	28.13	ND	664.44	664.44
	08/19/2013	ND	14.68	28.13	ND	664.37	664.37
	11/04/2013	ND	14.53	28.08	ND	664.52	664.52
	03/10/2014	ND	15.15	28.08	ND	663.90	663.90
	05/19/2014	ND	13.79	28.08	ND	665.26	665.26
	06/01/2015	ND	14.83	28.08	ND	664.22	664.22

Notes:
[Well Depth, Screen Interval] - Feet below ground surface
NC - Not Calculated - Top of casing elevation unknown, unable to calculate groundwater elevation
ND - Not Detected
NM - Not Measurable
NA - Not Available

Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
GM-2 [26.816, 6.816-26.516]							
	05/31/2016	ND	15.12	28.41	ND	663.93	663.93
	06/05/2017	ND	16.37	28.41	ND	662.68	662.68
	06/04/2018	ND	15.64	28.41	ND	663.41	663.41
GM-3 [29.385, 9.385-29.085]							
	11/13/2012	ND	17.99	30.45	ND	664.55	664.55
	02/18/2013	ND	17.97	30.50	ND	664.57	664.57
	05/20/2013	ND	17.71	30.50	ND	664.83	664.83
	08/19/2013	ND	17.96	30.50	ND	664.58	664.58
	11/04/2013	ND	16.81	30.50	ND	665.73	665.73
	03/10/2014	18.17	18.18	30.50	0.01	664.36	664.37
	05/19/2014	16.91	16.92	30.50	0.01	665.62	665.63
	06/01/2015	ND	17.46	30.50	ND	665.08	665.08
	05/31/2016	ND	17.61	30.49	ND	664.93	664.93
	06/05/2017	ND	19.07	30.49	ND	663.47	663.47
	06/04/2018	ND	18.13	30.49	ND	664.41	664.41
GM-3D [42.01, 32.01-41.71]							
	11/13/2012	ND	17.99	43.06	ND	664.55	664.55
	11/14/2012	ND	17.72	NA	ND	664.82	664.82
	02/18/2013	ND	17.98	43.08	ND	664.56	664.56
	05/20/2013	ND	17.73	43.08	ND	664.81	664.81
	08/19/2013	ND	17.93	43.08	ND	664.61	664.61
	11/04/2013	ND	17.78	43.17	ND	664.76	664.76
	11/05/2013	ND	17.62	NA	ND	664.92	664.92
	03/10/2014	ND	18.41	43.17	ND	664.13	664.13
	05/19/2014	ND	16.88	43.17	ND	665.66	665.66
	06/01/2015	ND	17.54	43.17	ND	665.00	665.00
	05/31/2016	ND	17.53	43.18	ND	665.01	665.01
	06/05/2017	ND	18.07	43.18	ND	664.47	664.47
	06/04/2018	ND	18.11	43.18	ND	664.43	664.43
GM-4 [28.275, 8.275-27.975]							
	11/13/2012	ND	13.86	28.95	ND	664.54	664.54
	02/18/2013	ND	13.85	28.90	ND	664.55	664.55

Notes:
[Well Depth, Screen Interval] - Feet below ground surface
NC - Not Calculated - Top of casing elevation unknown, unable to calculate groundwater elevation
ND - Not Detected
NM - Not Measurable
NA - Not Available

Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
GM-4 [28.275, 8.275-27.975]							
	05/20/2013	ND	13.60	28.90	ND	664.80	664.80
	08/19/2013	ND	13.74	28.90	ND	664.66	664.66
	11/04/2013	ND	13.59	28.88	ND	664.81	664.81
	03/10/2014	ND	14.01	28.88	ND	664.39	664.39
	05/19/2014	ND	12.69	28.88	ND	665.71	665.71
	06/01/2015	ND	13.44	28.88	ND	664.96	664.96
	05/31/2016	ND	13.52	29.25	ND	664.88	664.88
	06/05/2017	ND	13.80	29.25	ND	664.60	664.60
	06/04/2018	ND	13.95	29.25	ND	664.45	664.45
GM-5 [30.453, 10.453-30.153]							
	11/13/2012	ND	13.34	31.30	ND	664.59	664.59
	02/18/2013	ND	13.35	31.30	ND	664.58	664.58
	05/20/2013	ND	13.09	31.30	ND	664.84	664.84
	08/19/2013	ND	13.23	31.30	ND	664.70	664.70
	11/04/2013	ND	13.10	31.28	ND	664.83	664.83
	03/10/2014	ND	13.49	31.28	ND	664.44	664.44
	05/19/2014	ND	12.17	31.28	ND	665.76	665.76
	06/01/2015	ND	12.93	31.28	ND	665.00	665.00
	05/31/2016	ND	13.00	31.66	ND	664.93	664.93
	06/05/2017	ND	13.31	31.66	ND	664.62	664.62
	06/04/2018	ND	13.45	31.66	ND	664.48	664.48
GM-5D [59.012, 44.012-58.712]							
	11/13/2012	ND	13.40	59.85	ND	664.60	664.60
	02/18/2013	ND	13.41	59.83	ND	664.59	664.59
	05/20/2013	ND	13.15	59.83	ND	664.85	664.85
	08/19/2013	ND	13.30	59.83	ND	664.70	664.70
	11/04/2013	ND	13.14	59.85	ND	664.86	664.86
	03/10/2014	ND	13.56	59.85	ND	664.44	664.44
	05/19/2014	ND	12.24	59.85	ND	665.76	665.76
	06/01/2015	ND	12.98	59.85	ND	665.02	665.02
	05/31/2016	ND	13.06	60.79	ND	664.94	664.94
	06/05/2017	ND	13.42	60.79	ND	664.58	664.58

Notes:
[Well Depth, Screen Interval] - Feet below ground surface
NC - Not Calculated - Top of casing elevation unknown, unable to calculate groundwater elevation
ND - Not Detected
NM - Not Measurable
NA - Not Available

Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
GM-5D [59.012, 44.012-58.712]							
	06/04/2018	ND	13.53	60.79	ND	664.47	664.47
GM-6 [30.525, 10.525-30.225]							
	11/13/2012	ND	15.73	32.81	ND	664.54	664.54
	02/18/2013	ND	15.78	32.83	ND	664.49	664.49
	05/20/2013	ND	15.53	32.83	ND	664.74	664.74
	08/19/2013	ND	15.66	32.83	ND	664.61	664.61
	11/04/2013	ND	15.53	32.89	ND	664.74	664.74
	03/10/2014	ND	16.00	32.89	ND	664.27	664.27
	05/19/2014	ND	14.67	32.89	ND	665.60	665.60
	06/01/2015	ND	15.49	32.89	ND	664.78	664.78
	05/31/2016	ND	15.60	33.29	ND	664.67	664.67
	06/05/2017	ND	15.90	33.29	ND	664.37	664.37
	06/04/2018	ND	16.04	33.29	ND	664.23	664.23
GM-7 [23.809, 8.809-23.509]							
	11/13/2012	ND	17.60	24.78	ND	664.62	664.62
	02/18/2013	ND	17.57	24.78	ND	664.65	664.65
	05/20/2013	ND	17.23	24.78	ND	664.99	664.99
	08/19/2013	ND	17.30	24.78	ND	664.92	664.92
	11/04/2013	ND	17.29	24.79	ND	664.93	664.93
	03/10/2014	ND	17.77	24.79	ND	664.45	664.45
	05/19/2014	ND	16.33	24.79	ND	665.89	665.89
	06/01/2015	ND	17.09	24.79	ND	665.13	665.13
	05/31/2016	ND	17.05	24.99	ND	665.17	665.17
	06/05/2017	ND	16.95	24.99	ND	665.27	665.27
	06/04/2018	ND	17.02	24.99	ND	665.20	665.20
GM-8R [24.997, 14.997-24.697]							
	11/13/2012	ND	18.80	27.10	ND	664.56	664.56
	02/18/2013	ND	15.79	27.15	ND	667.57	667.57
	05/20/2013	ND	18.56	27.15	ND	664.80	664.80
	08/19/2013	ND	18.72	27.15	ND	664.64	664.64
	11/04/2013	ND	18.59	27.15	ND	664.77	664.77
	03/10/2014	ND	18.96	27.15	ND	664.40	664.40

Notes:
[Well Depth, Screen Interval] - Feet below ground surface
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ND - Not Detected
NM - Not Measurable
NA - Not Available

Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
GM-8R [24.997, 14.997-24.697]							
	05/19/2014	ND	17.66	27.15	ND	665.70	665.70
	06/01/2015	ND	18.27	27.15	ND	665.09	665.09
	05/31/2016	ND	18.39	27.12	ND	664.97	664.97
	06/05/2017	ND	18.79	27.12	ND	664.57	664.57
	06/04/2018	ND	18.82	27.12	ND	664.54	664.54
GM-10 [28.537, 13.537-28.237]							
	11/13/2012	ND	18.17	30.00	ND	664.40	664.40
	11/14/2012	ND	17.92	NA	ND	664.65	664.65
	02/18/2013	ND	18.19	30.00	ND	664.38	664.38
	05/20/2013	ND	17.91	30.00	ND	664.66	664.66
	08/19/2013	ND	18.10	30.00	ND	664.47	664.47
	11/04/2013	ND	17.92	30.00	ND	664.65	664.65
	11/06/2013	ND	17.84	NA	ND	664.73	664.73
	03/10/2014	ND	15.38	30.00	ND	667.19	667.19
	05/19/2014	ND	17.09	30.00	ND	665.48	665.48
	06/01/2015	ND	17.84	30.00	ND	664.73	664.73
	05/31/2016	ND	17.95	30.39	ND	664.62	664.62
	06/05/2017	ND	18.34	30.39	ND	664.23	664.23
	06/04/2018	ND	18.58	30.39	ND	663.99	663.99
GM-11 [19.838, 9.838-19.538]							
	11/13/2012	ND	12.19	18.38	ND	664.59	664.59
	11/15/2012	ND	12.29	NA	ND	664.49	664.49
	02/18/2013	ND	12.23	18.37	ND	664.55	664.55
	05/20/2013	ND	11.97	18.37	ND	664.81	664.81
	08/19/2013	ND	12.12	18.37	ND	664.66	664.66
	11/04/2013	ND	11.97	19.28	ND	664.81	664.81
	11/06/2013	ND	11.89	NA	ND	664.89	664.89
	03/10/2014	ND	12.38	19.28	ND	664.40	664.40
	05/19/2014	ND	11.16	19.28	ND	665.62	665.62
	06/01/2015	ND	12.02	19.28	ND	664.76	664.76
	05/31/2016	ND	11.87	18.45	ND	664.91	664.91
	06/05/2017	ND	11.83	18.45	ND	664.95	664.95

Notes:
[Well Depth, Screen Interval] - Feet below ground surface
NC - Not Calculated - Top of casing elevation unknown, unable to calculate groundwater elevation
ND - Not Detected
NM - Not Measurable
NA - Not Available

Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
GM-11 [19.838, 9.838-19.538]							
	06/04/2018	ND	12.30	18.45	ND	664.48	664.48
GM-12 [19.797, 9.797-19.497]							
	11/13/2012	ND	15.68	21.75	ND	664.53	664.53
	02/18/2013	ND	15.63	21.75	ND	664.58	664.58
	05/20/2013	ND	15.41	21.75	ND	664.80	664.80
	08/19/2013	ND	15.54	21.75	ND	664.67	664.67
	11/04/2013	ND	15.40	21.76	ND	664.81	664.81
	03/10/2014	ND	15.81	21.76	ND	664.40	664.40
	05/19/2014	ND	14.49	21.76	ND	665.72	665.72
	06/01/2015	ND	15.25	21.76	ND	664.96	664.96
	05/31/2016	ND	15.33	21.85	ND	664.88	664.88
	06/05/2017	ND	15.62	21.85	ND	664.59	664.59
	06/04/2018	ND	15.75	21.85	ND	664.46	664.46
GM-13 [18.343, 8.343-18.043]							
	11/13/2012	ND	13.71	20.10	ND	664.40	664.40
	02/18/2013	ND	13.75	20.13	ND	664.36	664.36
	05/20/2013	ND	13.50	20.13	ND	664.61	664.61
	08/19/2013	ND	13.62	20.13	ND	664.49	664.49
	11/04/2013	ND	13.50	20.11	ND	664.61	664.61
	03/10/2014	ND	13.97	20.11	ND	664.14	664.14
	05/19/2014	ND	12.60	20.11	ND	665.51	665.51
	06/01/2015	ND	13.47	20.11	ND	664.64	664.64
	05/31/2016	ND	13.64	20.09	ND	664.47	664.47
	06/05/2017	ND	13.94	20.09	ND	664.17	664.17
	06/04/2018	ND	14.08	20.09	ND	664.03	664.03
GM-14 [24.478, 9.478-24.178]							
	11/13/2012	ND	16.39	26.23	ND	664.64	664.64
	02/18/2013	ND	16.37	26.25	ND	664.66	664.66
	05/20/2013	ND	16.17	26.25	ND	664.86	664.86
	08/19/2013	ND	16.25	26.25	ND	664.78	664.78
	11/04/2013	ND	16.13	26.22	ND	664.90	664.90
	03/10/2014	ND	16.53	26.22	ND	664.50	664.50

Notes:
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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
GM-14 [24.478, 9.478-24.178]							
	05/19/2014	ND	15.16	26.22	ND	665.87	665.87
	06/01/2015	ND	15.93	26.22	ND	665.10	665.10
	05/31/2016	ND	16.10	26.33	ND	664.93	664.93
	06/05/2017	ND	16.30	26.33	ND	664.73	664.73
	06/04/2018	ND	16.42	26.33	ND	664.61	664.61
GM-15 [17.104, 4.604-16.804]							
	11/13/2012	ND	10.54	19.00	ND	665.25	665.25
	02/18/2013	ND	10.59	19.04	ND	665.20	665.20
	05/20/2013	ND	10.62	19.04	ND	665.17	665.17
	08/19/2013	ND	10.38	19.04	ND	665.41	665.41
	11/04/2013	ND	10.29	19.02	ND	665.50	665.50
	03/10/2014	ND	10.74	19.02	ND	665.05	665.05
	05/19/2014	ND	9.12	19.02	ND	666.67	666.67
	06/01/2015	ND	10.00	19.02	ND	665.79	665.79
	05/31/2016	ND	10.55	19.13	ND	665.24	665.24
	06/05/2017	ND	10.15	19.13	ND	665.64	665.64
	06/04/2018	ND	10.28	19.13	ND	665.51	665.51
MW-1 [31.587, 11.587-31.287]							
	11/13/2012	ND	19.30	33.21	ND	664.51	664.51
	11/14/2012	ND	19.03	NA	ND	664.78	664.78
	02/18/2013	ND	19.31	33.20	ND	664.50	664.50
	05/20/2013	ND	18.12	33.20	ND	665.69	665.69
	08/19/2013	ND	19.20	33.20	ND	664.61	664.61
	11/04/2013	ND	18.99	33.23	ND	664.82	664.82
	11/05/2013	ND	18.89	NA	ND	664.92	664.92
	03/10/2014	ND	19.47	33.23	ND	664.34	664.34
	05/19/2014	ND	18.16	33.23	ND	665.65	665.65
	06/01/2015	ND	18.90	33.23	ND	664.91	664.91
	05/31/2016	ND	18.91	33.67	ND	664.90	664.90
	06/05/2017	ND	19.29	33.67	ND	664.52	664.52
	06/04/2018	ND	19.43	33.67	ND	664.38	664.38

Notes:
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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
MW-2 [29.759, 9.759-29.459]							
	11/13/2012	ND	17.94	31.63	ND	664.84	664.84
	02/18/2013	ND	17.95	31.65	ND	664.83	664.83
	05/20/2013	ND	17.71	31.65	ND	665.07	665.07
	08/19/2013	ND	17.83	31.65	ND	664.95	664.95
	11/04/2013	ND	17.72	31.67	ND	665.06	665.06
	03/10/2014	ND	18.12	31.67	ND	664.66	664.66
	05/19/2014	ND	16.76	31.67	ND	666.02	666.02
	06/01/2015	ND	17.49	31.67	ND	665.29	665.29
	05/31/2016	ND	17.58	31.59	ND	665.20	665.20
	06/05/2017	ND	18.14	31.59	ND	664.64	664.64
	06/04/2018	ND	17.94	31.59	ND	664.84	664.84
MW-3 [30.724, 10.724-30.424]							
	11/13/2012	ND	20.40	33.75	ND	664.90	664.90
	11/14/2012	ND	20.20	NA	ND	665.10	665.10
	02/18/2013	ND	20.43	33.73	ND	664.87	664.87
	05/20/2013	ND	20.18	33.73	ND	665.12	665.12
	08/19/2013	ND	20.34	33.73	ND	664.96	664.96
	11/04/2013	ND	20.24	33.73	ND	665.06	665.06
	11/05/2013	ND	20.06	NA	ND	665.24	665.24
	03/10/2014	ND	20.63	33.73	ND	664.67	664.67
	05/19/2014	ND	19.25	33.73	ND	666.05	666.05
	06/01/2015	ND	19.94	33.73	ND	665.36	665.36
	05/31/2016	ND	20.05	34.03	ND	665.25	665.25
	06/05/2017	ND	20.74	34.03	ND	664.56	664.56
	06/04/2018	ND	20.42	30.72	ND	664.88	664.88
MW-4 [30.49, 10.49-30.19]							
	11/13/2012	ND	17.51	31.20	ND	664.96	664.96
	11/15/2012	ND	17.48	NA	ND	664.99	664.99
	02/18/2013	ND	17.55	31.20	ND	664.92	664.92
	05/20/2013	ND	17.37	31.20	ND	665.10	665.10
	08/19/2013	ND	17.44	31.20	ND	665.03	665.03
	11/04/2013	ND	17.37	31.25	ND	665.10	665.10

Notes:
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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
MW-4 [30.49, 10.49-30.19]							
	11/06/2013	ND	17.37	NA	ND	665.10	665.10
	03/10/2014	ND	17.82	31.25	ND	664.65	664.65
	05/19/2014	ND	16.32	31.25	ND	666.15	666.15
	06/01/2015	ND	17.23	31.25	ND	665.24	665.24
	05/31/2016	ND	17.36	30.45	ND	665.11	665.11
	06/05/2017	ND	17.83	30.45	ND	664.64	664.64
	06/04/2018	ND	17.67	31.25	ND	664.80	664.80
MW-4D [40.09, 30.09-39.79]							
	11/13/2012	ND	17.72	41.89	ND	664.93	664.93
	02/18/2013	ND	17.77	41.85	ND	664.88	664.88
	05/20/2013	ND	17.60	41.85	ND	665.05	665.05
	08/19/2013	ND	17.67	41.85	ND	664.98	664.98
	11/04/2013	ND	17.59	41.85	ND	665.06	665.06
	03/10/2014	ND	18.04	41.85	ND	664.61	664.61
	05/19/2014	ND	16.53	41.85	ND	666.12	666.12
	06/01/2015	ND	17.45	41.85	ND	665.20	665.20
	05/31/2016	ND	17.58	41.80	ND	665.07	665.07
	06/05/2017	ND	18.05	41.80	ND	664.60	664.60
	06/04/2018	ND	17.89	41.80	ND	664.76	664.76
MW-5 [29.838, 9.838-29.538]							
	11/13/2012	17.73	17.86	31.83	0.13	664.71	664.80
	11/14/2012	ND	17.86	NA	ND	664.71	664.71
	02/18/2013	17.68	17.90	31.82	0.22	664.67	664.83
	05/20/2013	17.59	17.85	31.82	0.26	664.72	664.91
	05/21/2013	ND	17.85	NA	ND	664.72	664.72
	08/19/2013	17.54	17.93	31.82	0.39	664.64	664.92
	08/20/2013	ND	17.93	NA	ND	664.64	664.64
	11/04/2013	17.48	17.83	31.81	0.35	664.74	665.00
	03/10/2014	17.94	17.96	31.81	0.02	664.61	664.62
	05/19/2014	16.48	16.57	31.81	0.09	666.00	666.07
	06/01/2015	17.36	17.36	31.81	0.00	665.21	665.21
	05/31/2016	17.57	17.82	NA	0.25	664.75	664.93

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
MW-5 [29.838, 9.838-29.538]							
	06/05/2017	Well Not Gauged					
	06/04/2018	Well Not Gauged - Well obstructed at 12.60					
MW-6 [25.326, 10.326-25.026]							
	11/13/2012	ND	18.09	27.30	ND	664.98	664.98
	02/18/2013	ND	18.08	27.25	ND	664.99	664.99
	05/20/2013	Well Not Gauged					
	08/19/2013	ND	17.95	27.25	ND	665.12	665.12
	11/04/2013	ND	17.92	27.28	ND	665.15	665.15
	03/10/2014	ND	18.36	27.28	ND	664.71	664.71
	05/19/2014	ND	16.91	27.28	ND	666.16	666.16
	06/01/2015	ND	17.69	27.28	ND	665.38	665.38
	05/31/2016	ND	17.95	27.27	ND	665.12	665.12
	06/05/2017	ND	18.28	27.27	ND	664.79	664.79
	06/04/2018	ND	18.12	27.27	ND	664.95	664.95
MW-7 [27.358, 12.358-27.058]							
	11/13/2012	ND	17.98	28.93	ND	664.96	664.96
	11/15/2012	ND	17.99	NA	ND	664.95	664.95
	02/18/2013	ND	17.96	28.95	ND	664.98	664.98
	05/20/2013	ND	17.86	28.95	ND	665.08	665.08
	08/19/2013	ND	17.92	28.95	ND	665.02	665.02
	11/04/2013	ND	17.85	28.33	ND	665.09	665.09
	11/06/2013	ND	17.86	NA	ND	665.08	665.08
	03/10/2014	18.27	18.40	28.33	0.13	664.54	664.63
	05/19/2014	16.79	16.81	28.33	0.02	666.13	666.14
	06/01/2015	17.65	18.01	28.33	0.36	664.93	665.19
	05/31/2016	17.78	18.28	28.95	0.50	664.66	665.03
	06/05/2017	18.24	18.67	28.95	0.43	664.27	664.58
	06/04/2018	18.13	18.24	28.93	0.11	664.70	664.78
MW-8 [26.261, 11.261-25.961]							
	11/13/2012	ND	18.31	28.22	ND	664.83	664.83
	11/15/2012	ND	18.24	NA	ND	664.90	664.90
	02/18/2013	ND	18.29	28.22	ND	664.85	664.85

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
MW-8 [26.261, 11.261-25.961]							
	05/20/2013	ND	18.14	28.22	ND	665.00	665.00
	08/19/2013	ND	18.17	28.22	ND	664.97	664.97
	11/04/2013	ND	18.10	28.24	ND	665.04	665.04
	11/05/2013	ND	17.97	NA	ND	665.17	665.17
	03/10/2014	ND	18.53	28.24	ND	664.61	664.61
	05/19/2014	ND	17.09	28.24	ND	666.05	666.05
	06/01/2015	ND	17.86	28.24	ND	665.28	665.28
	05/31/2016	ND	18.11	28.25	ND	665.03	665.03
	06/05/2017	ND	18.45	28.25	ND	664.69	664.69
	06/04/2018	ND	18.30	28.25	ND	664.84	664.84
MW-9 [25.034, 10.034-24.734]							
	11/13/2012	16.67	16.68	26.97	0.01	664.96	664.97
	11/14/2012	ND	16.68	NA	ND	664.96	664.96
	02/18/2013	ND	16.68	27.00	ND	664.96	664.96
	05/20/2013	ND	16.53	27.00	ND	665.11	665.11
	08/19/2013	ND	16.56	27.00	ND	665.08	665.08
	11/04/2013	16.54	16.55	26.91	0.01	665.09	665.10
	03/10/2014	16.98	17.00	26.91	0.02	664.64	664.65
	05/19/2014	15.47	15.48	26.91	0.01	666.16	666.17
	06/01/2015	16.38	16.39	26.91	0.01	665.25	665.26
	05/31/2016	16.57	16.59	NA	0.02	665.05	665.06
	06/05/2017	16.93	16.94	NA	0.01	664.70	664.71
	06/04/2018	ND	16.04	26.91	ND	665.60	665.60
MW-10 [24.941, 9.941-24.641]							
	11/13/2012	ND	17.86	26.68	ND	664.81	664.81
	11/14/2012	ND	17.65	NA	ND	665.02	665.02
	02/18/2013	ND	17.86	26.67	ND	664.81	664.81
	05/20/2013	ND	17.66	26.67	ND	665.01	665.01
	08/19/2013	ND	17.74	26.67	ND	664.93	664.93
	11/04/2013	ND	17.69	26.65	ND	664.98	664.98
	11/06/2013	ND	17.62	NA	ND	665.05	665.05
	03/10/2014	ND	18.13	26.65	ND	664.54	664.54

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
MW-10 [24.941, 9.941-24.641]							
	05/19/2014	ND	16.71	26.65	ND	665.96	665.96
	06/01/2015	ND	17.39	26.65	ND	665.28	665.28
	05/31/2016	ND	17.71	26.70	ND	664.96	664.96
	06/05/2017	ND	18.16	26.70	ND	664.51	664.51
	06/04/2018	ND	17.89	26.70	ND	664.78	664.78
MW-11R [23.223, 13.223-22.923]							
	11/13/2012	ND	15.75	23.00	ND	665.01	665.01
	02/18/2013	ND	15.80	23.05	ND	664.96	664.96
	05/20/2013	ND	17.60	23.05	ND	663.16	663.16
	08/19/2013	ND	15.70	23.05	ND	665.06	665.06
	11/04/2013	ND	15.65	23.04	ND	665.11	665.11
	03/10/2014	ND	16.10	23.04	ND	664.66	664.66
	05/19/2014	ND	14.57	23.04	ND	666.19	666.19
	06/01/2015	ND	15.39	23.04	ND	665.37	665.37
	05/31/2016	15.67	15.68	23.00	0.01	665.08	665.09
	06/05/2017	ND	16.09	23.00	ND	664.67	664.67
	06/04/2018	ND	15.92	23.00	ND	664.84	664.84
MW-12 [26.692, 11.692-26.392]							
	11/13/2012	ND	17.37	27.80	ND	664.98	664.98
	02/18/2013	ND	17.38	27.72	ND	664.97	664.97
	05/20/2013	ND	17.22	27.72	ND	665.13	665.13
	08/19/2013	ND	17.25	27.72	ND	665.10	665.10
	11/04/2013	ND	17.20	27.80	ND	665.15	665.15
	03/10/2014	ND	17.62	27.80	ND	664.73	664.73
	05/19/2014	ND	16.10	27.80	ND	666.25	666.25
	06/01/2015	ND	16.95	27.80	ND	665.40	665.40
	05/31/2016	ND	17.20	27.80	ND	665.15	665.15
	06/05/2017	ND	17.53	27.80	ND	664.82	664.82
	06/04/2018	ND	17.38	27.80	ND	664.97	664.97
MW-13R [23.213, 13.213-22.913]							
	11/13/2012	ND	15.38	22.60	ND	664.89	664.89
	02/18/2013	ND	15.35	22.60	ND	664.92	664.92

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	*Date*	*Depth to SPL(ft)*	*Depth to Water (ft)*	*Depth to Bottom (ft)*	*SPL Thickness(ft)*	*Groundwater Elevation (ft)*	*Corrected GW Elevation (ft)*
MW-13R [23.213, 13.213-22.913]							
	05/20/2013	ND	15.28	22.60	ND	664.99	664.99
	08/19/2013	ND	15.24	22.60	ND	665.03	665.03
	11/04/2013	ND	15.19	22.65	ND	665.08	665.08
	03/10/2014	ND	15.55	22.65	ND	664.72	664.72
	05/19/2014	ND	14.05	22.65	ND	666.22	666.22
	06/01/2015	ND	15.13	22.65	ND	665.14	665.14
	05/31/2016	ND	15.21	21.49	ND	665.06	665.06
	06/05/2017	ND	15.33	21.49	ND	664.94	664.94
	06/04/2018	ND	15.29	22.64	ND	664.98	664.98
MW-14 [24.528, 9.528-24.228]							
	11/13/2012	ND	15.58	23.92	ND	665.01	665.01
	02/18/2013	ND	15.55	23.95	ND	665.04	665.04
	05/20/2013	ND	15.57	23.95	ND	665.02	665.02
	08/19/2013	ND	15.52	23.95	ND	665.07	665.07
	11/04/2013	15.41	15.42	23.91	0.01	665.17	665.18
	03/10/2014	ND	15.76	23.91	ND	664.83	664.83
	05/19/2014	ND	14.46	23.91	ND	666.13	666.13
	06/01/2015	ND	15.38	23.91	ND	665.21	665.21
	05/31/2016	15.55	15.56	NA	0.01	665.03	665.04
	06/05/2017	15.64	15.66	NA	0.02	664.93	664.94
	06/04/2018	15.67	15.69	24.20	0.02	664.90	664.91
MW-15 [24.878, 9.878-24.578]							
	11/13/2012	15.43	15.74	23.65	0.31	664.68	664.91
	02/18/2013	15.48	15.88	23.70	0.40	664.54	664.83
	05/20/2013	15.28	16.38	23.70	1.10	664.04	664.84
	08/19/2013	15.34	16.35	23.70	1.01	664.07	664.81
	11/04/2013	15.32	15.39	23.67	0.07	665.03	665.08
	03/10/2014	15.67	16.69	23.67	1.02	663.73	664.47
	05/19/2014	14.63	14.69	23.67	0.06	665.73	665.77
	06/01/2015	15.24	15.87	23.67	0.63	664.55	665.01
	05/31/2016	15.21	16.54	NA	1.33	663.88	664.85
	06/05/2017	15.41	17.73	NA	2.32	662.69	664.38

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Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
MW-15 [24.878, 9.878-24.578]							
	06/04/2018	15.47	17.85	24.35	2.38	662.57	664.31
MW-16 [25.95, 10.95-25.65]							
	11/13/2012	ND	15.58	25.58	ND	664.88	664.88
	02/18/2013	ND	15.60	25.55	ND	664.86	664.86
	05/20/2013	ND	15.47	25.55	ND	664.99	664.99
	08/19/2013	ND	15.47	25.55	ND	664.99	664.99
	11/04/2013	ND	15.32	25.55	ND	665.14	665.14
	03/10/2014	ND	15.80	25.55	ND	664.66	664.66
	05/19/2014	ND	14.68	25.55	ND	665.78	665.78
	06/01/2015	ND	15.36	25.55	ND	665.10	665.10
	05/31/2016	ND	15.44	25.80	ND	665.02	665.02
	06/05/2017	ND	15.49	25.80	ND	664.97	664.97
	06/04/2018	ND	15.59	25.80	ND	664.87	664.87
MW-17 [25.865, 10.865-25.565]							
	11/13/2012	ND	15.88	24.90	ND	664.68	664.68
	02/18/2013	ND	15.88	24.87	ND	664.68	664.68
	05/20/2013	ND	15.65	24.87	ND	664.91	664.91
	08/19/2013	ND	15.76	24.87	ND	664.80	664.80
	11/04/2013	ND	15.63	25.88	ND	664.93	664.93
	03/10/2014	ND	16.07	25.88	ND	664.49	664.49
	05/19/2014	ND	14.72	25.88	ND	665.84	665.84
	06/01/2015	ND	15.53	25.88	ND	665.03	665.03
	05/31/2016	ND	15.58	25.05	ND	664.98	664.98
	06/05/2017	ND	15.95	25.05	ND	664.61	664.61
	06/04/2018	ND	15.91	25.05	ND	664.65	664.65
MW-18 [26.337, 11.337-26.037]							
	11/13/2012	ND	15.86	25.76	ND	664.63	664.63
	02/18/2013	ND	15.86	25.76	ND	664.63	664.63
	05/20/2013	ND	15.67	25.76	ND	664.82	664.82
	08/19/2013	ND	15.73	25.76	ND	664.76	664.76
	11/04/2013	ND	15.60	25.73	ND	664.89	664.89
	03/10/2014	ND	16.04	25.73	ND	664.45	664.45

Notes:
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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
MW-18 [26.337, 11.337-26.037]							
	05/19/2014	ND	14.68	25.73	ND	665.81	665.81
	06/01/2015	ND	15.53	25.73	ND	664.96	664.96
	05/31/2016	ND	15.56	26.05	ND	664.93	664.93
	06/05/2017	ND	15.90	26.05	ND	664.59	664.59
	06/04/2018	ND	15.90	26.05	ND	664.59	664.59
MW-19 [25.864, 10.864-25.564]							
	11/13/2012	ND	16.22	24.93	ND	664.56	664.56
	02/18/2013	ND	16.20	24.95	ND	664.58	664.58
	05/20/2013	ND	15.94	24.95	ND	664.84	664.84
	08/19/2013	ND	16.20	24.95	ND	664.58	664.58
	11/04/2013	ND	15.92	24.92	ND	664.86	664.86
	03/10/2014	ND	16.40	24.92	ND	664.38	664.38
	05/19/2014	ND	15.03	24.92	ND	665.75	665.75
	06/01/2015	ND	15.85	24.92	ND	664.93	664.93
	05/31/2016	ND	15.88	23.85	ND	664.90	664.90
	06/05/2017	ND	16.06	23.85	ND	664.72	664.72
	06/04/2018	ND	16.03	23.85	ND	664.75	664.75
MW-20 [18.593, 8.593-18.293]							
	11/13/2012	ND	15.81	21.20	ND	664.58	664.58
	02/18/2013	ND	15.83	21.21	ND	664.56	664.56
	05/20/2013	ND	15.59	21.21	ND	664.80	664.80
	08/19/2013	ND	15.71	21.21	ND	664.68	664.68
	11/04/2013	ND	15.57	21.23	ND	664.82	664.82
	03/10/2014	ND	15.97	21.23	ND	664.42	664.42
	05/19/2014	ND	14.67	21.23	ND	665.72	665.72
	06/01/2015	ND	15.44	21.23	ND	664.95	664.95
	05/31/2016	ND	15.53	21.25	ND	664.86	664.86
	06/05/2017	ND	15.84	21.25	ND	664.55	664.55
	06/04/2018	ND	15.92	21.25	ND	664.47	664.47
MW-21 [25.759, 15.759-25.459]							
	11/13/2012	ND	20.04	27.67	ND	664.76	664.76
	02/18/2013	ND	20.01	27.68	ND	664.79	664.79

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
MW-21 [25.759, 15.759-25.459]							
	05/20/2013	ND	19.81	27.68	ND	664.99	664.99
	08/19/2013	ND	19.91	27.68	ND	664.89	664.89
	11/04/2013	ND	19.79	27.64	ND	665.01	665.01
	03/10/2014	ND	20.21	27.64	ND	664.59	664.59
	05/19/2014	ND	18.86	27.64	ND	665.94	665.94
	06/01/2015	ND	18.69	27.64	ND	666.11	666.11
	05/31/2016	ND	19.73	27.70	ND	665.07	665.07
	06/05/2017	ND	20.12	27.70	ND	664.68	664.68
	06/04/2018	ND	20.03	27.70	ND	664.77	664.77
MW-22 [26.291, 16.291-25.991]							
	11/13/2012	ND	19.85	29.40	ND	664.80	664.80
	11/14/2012	ND	19.63	NA	ND	665.02	665.02
	02/18/2013	ND	19.84	29.41	ND	664.81	664.81
	05/20/2013	ND	19.62	29.41	ND	665.03	665.03
	08/19/2013	ND	19.70	29.41	ND	664.95	664.95
	11/04/2013	ND	19.60	25.41	ND	665.05	665.05
	11/05/2013	ND	19.45	NA	ND	665.20	665.20
	03/10/2014	ND	20.00	25.41	ND	664.65	664.65
	05/19/2014	ND	18.62	25.41	ND	666.03	666.03
	06/01/2015	ND	19.36	25.41	ND	665.29	665.29
	05/31/2016	ND	19.45	29.57	ND	665.20	665.20
	06/05/2017	ND	19.95	29.57	ND	664.70	664.70
	06/04/2018	ND	19.80	29.57	ND	664.85	664.85
MW-23 [27.119, 17.119-26.819]							
	11/13/2012	ND	21.39	30.38	ND	664.85	664.85
	02/18/2013	ND	21.41	30.39	ND	664.83	664.83
	05/20/2013	ND	21.18	30.39	ND	665.06	665.06
	08/19/2013	ND	21.29	30.39	ND	664.95	664.95
	11/04/2013	ND	21.20	30.38	ND	665.04	665.04
	03/10/2014	ND	21.57	30.38	ND	664.67	664.67
	05/19/2014	ND	20.22	30.38	ND	666.02	666.02
	06/01/2015	ND	20.93	30.38	ND	665.31	665.31

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
MW-23 [27.119, 17.119-26.819]							
	05/31/2016	ND	21.03	30.51	ND	665.21	665.21
	06/05/2017	ND	21.60	30.51	ND	664.64	664.64
	06/04/2018	ND	21.40	30.51	ND	664.84	664.84
MW-24 [27.225, 17.225-26.925]							
	11/13/2012	ND	21.60	30.30	ND	664.93	664.93
	11/14/2012	ND	21.37	NA	ND	665.16	665.16
	02/18/2013	ND	21.62	30.30	ND	664.91	664.91
	05/20/2013	ND	21.39	30.30	ND	665.14	665.14
	08/19/2013	ND	19.02	30.30	ND	667.51	667.51
	11/04/2013	ND	21.43	30.28	ND	665.10	665.10
	11/05/2013	ND	21.23	NA	ND	665.30	665.30
	03/10/2014	ND	21.78	30.28	ND	664.75	664.75
	05/19/2014	ND	20.44	30.28	ND	666.09	666.09
	06/01/2015	ND	21.12	30.28	ND	665.41	665.41
	05/31/2016	ND	21.21	30.32	ND	665.32	665.32
	06/05/2017	ND	21.85	30.32	ND	664.68	664.68
	06/04/2018	ND	21.62	30.30	ND	664.91	664.91
MW-25 [26.678, 16.678-26.378]							
	11/13/2012	ND	21.65	29.33	ND	664.87	664.87
	02/18/2013	ND	21.67	29.34	ND	664.85	664.85
	05/20/2013	ND	21.43	29.34	ND	665.09	665.09
	08/19/2013	ND	21.57	29.34	ND	664.95	664.95
	11/04/2013	ND	21.49	29.33	ND	665.03	665.03
	03/10/2014	ND	21.84	29.33	ND	664.68	664.68
	05/19/2014	ND	20.48	29.33	ND	666.04	666.04
	06/01/2015	ND	21.19	29.33	ND	665.33	665.33
	05/31/2016	ND	21.29	29.35	ND	665.23	665.23
	06/05/2017	ND	21.92	29.35	ND	664.60	664.60
	06/04/2018	ND	21.68	29.35	ND	664.84	664.84
MW-26D [68.88, 58.88-68.58]							
	11/13/2012	ND	21.31	72.03	ND	664.89	664.89
	02/18/2013	ND	21.44	72.15	ND	664.76	664.76

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
MW-26D [68.88, 58.88-68.58]							
	05/20/2013	ND	21.09	72.15	ND	665.11	665.11
	08/19/2013	ND	21.57	72.15	ND	664.63	664.63
	11/04/2013	ND	21.19	72.04	ND	665.01	665.01
	11/06/2013	ND	21.17	NA	ND	665.03	665.03
	03/10/2014	ND	21.43	52.76	ND	664.77	664.77
	05/19/2014	ND	20.39	52.76	ND	665.81	665.81
	06/01/2015	ND	20.99	52.76	ND	665.21	665.21
	05/31/2016	ND	21.05	52.75	ND	665.15	665.15
	06/05/2017	ND	22.16	52.75	ND	664.04	664.04
	06/04/2018	ND	21.64	52.75	ND	664.56	664.56
MW-26E [50.19, 40.19-49.89]							
	11/13/2012	ND	21.15	53.30	ND	664.90	664.90
	02/18/2013	ND	21.21	57.75	ND	664.84	664.84
	05/20/2013	ND	20.93	57.75	ND	665.12	665.12
	08/19/2013	ND	21.25	57.75	ND	664.80	664.80
	11/04/2013	ND	21.02	52.76	ND	665.03	665.03
	11/06/2013	ND	20.98	NA	ND	665.07	665.07
	03/10/2014	ND	21.61	72.04	ND	664.44	664.44
	05/19/2014	ND	20.12	72.04	ND	665.93	665.93
	06/01/2015	ND	20.77	72.04	ND	665.28	665.28
	05/31/2016	ND	21.35	72.88	ND	664.70	664.70
	06/05/2017	ND	21.79	72.88	ND	664.26	664.26
	06/04/2018	ND	21.41	52.73	ND	664.64	664.64
MW-26S [25.9, 15.9-25.6]							
	11/13/2012	ND	21.51	28.45	ND	664.93	664.93
	02/18/2013	ND	21.54	28.43	ND	664.90	664.90
	05/20/2013	ND	21.31	28.43	ND	665.13	665.13
	08/19/2013	ND	21.47	28.43	ND	664.97	664.97
	11/04/2013	ND	21.39	28.44	ND	665.05	665.05
	11/05/2013	ND	21.24	NA	ND	665.20	665.20
	03/10/2014	ND	21.79	28.44	ND	664.65	664.65
	05/19/2014	ND	20.39	28.44	ND	666.05	666.05

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
MW-26S [25.9, 15.9-25.6]							
	06/01/2015	ND	21.10	28.44	ND	665.34	665.34
	05/31/2016	ND	21.30	28.59	ND	665.14	665.14
	06/05/2017	ND	22.00	28.59	ND	664.44	664.44
	06/04/2018	ND	21.74	28.59	ND	664.70	664.70
MW-27 [22.133, 12.133-21.833]							
	11/13/2012	ND	17.70	24.47	ND	664.80	664.80
	02/18/2013	ND	17.68	24.48	ND	664.82	664.82
	05/20/2013	ND	17.51	24.48	ND	664.99	664.99
	08/19/2013	ND	17.57	24.48	ND	664.93	664.93
	11/04/2013	ND	17.48	24.46	ND	665.02	665.02
	03/10/2014	ND	17.89	24.46	ND	664.61	664.61
	05/19/2014	ND	16.48	24.46	ND	666.02	666.02
	06/01/2015	ND	17.33	24.46	ND	665.17	665.17
	05/31/2016	ND	17.56	24.45	ND	664.94	664.94
	06/05/2017	ND	17.86	24.45	ND	664.64	664.64
	06/04/2018	ND	17.31	24.45	ND	665.19	665.19
MW-29 [22.495, 12.495-22.195]							
	11/13/2012	ND	18.33	24.95	ND	664.68	664.68
	02/18/2013	ND	18.33	24.94	ND	664.68	664.68
	05/20/2013	ND	18.10	24.94	ND	664.91	664.91
	08/19/2013	ND	18.24	24.94	ND	664.77	664.77
	11/04/2013	ND	18.10	24.93	ND	664.91	664.91
	03/10/2014	ND	18.54	24.93	ND	664.47	664.47
	05/19/2014	ND	17.28	24.93	ND	665.73	665.73
	06/01/2015	ND	19.98	24.93	ND	663.03	663.03
	05/31/2016	ND	18.05	24.94	ND	664.96	664.96
	06/05/2017	ND	18.52	24.94	ND	664.49	664.49
	06/04/2018	ND	18.48	24.93	ND	664.53	664.53
MW-30 [22.998, 12.998-22.698]							
	11/13/2012	ND	18.63	25.48	ND	664.74	664.74
	02/18/2013	ND	18.63	25.49	ND	664.74	664.74
	05/20/2013	ND	18.39	25.49	ND	664.98	664.98

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	*Date*	*Depth to SPL(ft)*	*Depth to Water (ft)*	*Depth to Bottom (ft)*	*SPL Thickness(ft)*	*Groundwater Elevation (ft)*	*Corrected GW Elevation (ft)*
MW-30 [22.998, 12.998-22.698]							
	08/19/2013	ND	18.52	25.49	ND	664.85	664.85
	11/04/2013	ND	18.40	25.49	ND	664.97	664.97
	03/10/2014	ND	18.81	25.49	ND	664.56	664.56
	05/19/2014	ND	17.45	25.49	ND	665.92	665.92
	06/01/2015	ND	18.24	25.49	ND	665.13	665.13
	05/31/2016	ND	18.33	25.51	ND	665.04	665.04
	06/05/2017	ND	18.78	25.51	ND	664.59	664.59
	06/04/2018	ND	18.67	25.51	ND	664.70	664.70
MW-31 [22.87, 12.87-22.57]							
	11/13/2012	ND	15.33	22.71	ND	664.88	664.88
	11/16/2012	ND	15.33	NA	ND	664.88	664.88
	02/18/2013	ND	15.32	22.75	ND	664.89	664.89
	02/19/2013	ND	15.48	NA	ND	664.73	664.73
	05/20/2013	ND	15.82	22.75	ND	664.39	664.39
	05/21/2013	ND	15.07	NA	ND	665.14	665.14
	08/19/2013	ND	15.27	22.70	ND	664.94	664.94
	08/20/2013	ND	15.05	NA	ND	665.16	665.16
	11/04/2013	ND	15.16	22.73	ND	665.05	665.05
	11/07/2013	ND	14.93	NA	ND	665.28	665.28
	03/10/2014	15.58	15.73	22.73	0.15	664.48	664.59
	05/19/2014	14.15	14.17	22.73	0.02	666.04	666.05
	06/01/2015	ND	15.09	22.73	ND	665.12	665.12
	05/31/2016	ND	15.16	22.71	ND	665.05	665.05
	06/05/2017	15.52	15.53	22.71	0.01	664.68	664.69
	06/04/2018	ND	15.49	22.70	ND	664.72	664.72
MW-32 [22.97, 12.97-22.67]							
	11/13/2012	ND	15.66	22.71	ND	664.88	664.88
	02/18/2013	ND	15.65	22.75	ND	664.89	664.89
	05/20/2013	Well Not Gauged - Covered by equipment		22.75			
	08/19/2013	15.57	15.66	22.75	0.09	664.88	664.95
	11/04/2013	15.48	15.50	22.74	0.02	665.04	665.05
	03/10/2014	ND	15.93	22.74	ND	664.61	664.61

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Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
MW-32 [22.97, 12.97-22.67]							
	05/19/2014	14.48	14.49	22.74	0.01	666.05	666.06
	06/01/2015	ND	15.32	22.74	ND	665.22	665.22
	05/31/2016	15.53	15.55	NA	0.02	664.99	665.00
	06/05/2017	ND	15.77	NA	ND	664.77	664.77
	06/04/2018	ND	15.76	22.74	ND	664.78	664.78
MW-33 [21.99, 11.99-21.69]							
	11/13/2012	ND	15.37	21.80	ND	664.93	664.93
	02/18/2013	ND	15.17	21.85	ND	665.13	665.13
	05/20/2013	ND	15.27	21.85	ND	665.03	665.03
	08/19/2013	ND	15.27	21.85	ND	665.03	665.03
	11/04/2013	ND	15.22	21.83	ND	665.08	665.08
	03/10/2014	ND	15.67	21.83	ND	664.63	664.63
	05/19/2014	ND	14.18	21.83	ND	666.12	666.12
	06/01/2015	ND	15.07	21.83	ND	665.23	665.23
	05/31/2016	ND	15.26	21.82	ND	665.04	665.04
	06/05/2017	ND	15.52	21.82	ND	664.78	664.78
	06/04/2018	ND	15.47	21.82	ND	664.83	664.83
MW-34 [23.119, 13.119-22.819]							
	11/13/2012	ND	15.38	22.05	ND	665.02	665.02
	02/18/2013	ND	15.39	22.10	ND	665.01	665.01
	05/20/2013	ND	15.30	22.10	ND	665.10	665.10
	08/19/2013	ND	15.24	22.10	ND	665.16	665.16
	11/04/2013	ND	15.20	22.97	ND	665.20	665.20
	03/10/2014	ND	15.62	22.97	ND	664.78	664.78
	05/19/2014	ND	14.08	22.97	ND	666.32	666.32
	06/01/2015	ND	14.95	22.97	ND	665.45	665.45
	05/31/2016	ND	15.20	21.95	ND	665.20	665.20
	06/05/2017	ND	15.60	21.95	ND	664.80	664.80
	06/04/2018	ND	15.46	21.95	ND	664.94	664.94
MW-35 [24.65, 14.65-24.35]							
	11/13/2012	ND	21.35	27.40	ND	664.92	664.92
	02/18/2013	ND	21.39	27.43	ND	664.88	664.88

Notes:
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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	*Date*	*Depth to SPL(ft)*	*Depth to Water (ft)*	*Depth to Bottom (ft)*	*SPL Thickness(ft)*	*Groundwater Elevation (ft)*	*Corrected GW Elevation (ft)*
MW-35 [24.65, 14.65-24.35]							
	05/20/2013	ND	21.16	27.43	ND	665.11	665.11
	08/19/2013	ND	21.32	27.43	ND	664.95	664.95
	11/04/2013	ND	21.24	27.41	ND	665.03	665.03
	03/10/2014	ND	21.64	27.41	ND	664.63	664.63
	05/19/2014	ND	20.25	27.41	ND	666.02	666.02
	06/01/2015	ND	20.97	27.41	ND	665.30	665.30
	05/31/2016	ND	21.13	27.65	ND	665.14	665.14
	06/05/2017	ND	22.85	27.65	ND	663.42	663.42
	06/04/2018	ND	21.59	27.65	ND	664.68	664.68
MW-37 [22.943, 12.943-22.643]							
	11/13/2012	16.18	17.45	22.70	1.27	662.81	663.74
	02/18/2013	16.16	16.70	22.80	0.54	663.56	663.95
	05/20/2013	16.05	17.41	22.80	1.36	662.85	663.84
	08/19/2013	16.12	17.74	22.80	1.62	662.52	663.70
	11/04/2013	16.02	17.60	22.70	1.58	662.66	663.81
	03/10/2014	16.48	18.06	22.70	1.58	662.20	663.35
	05/19/2014	15.01	16.60	22.70	1.59	663.66	664.82
	06/01/2015	15.82	17.32	22.70	1.50	662.94	664.04
	05/31/2016	16.02	17.48	NA	1.46	662.78	663.85
	06/05/2017	15.16	16.43	NA	1.27	663.83	664.76
	06/04/2018	16.31	17.97	22.33	1.66	662.29	663.50
MW-38R [24.51, 14.51-24.21]							
	11/13/2012	ND	15.88	24.97	ND	664.85	664.85
	11/16/2012	ND	15.50	NA	ND	665.23	665.23
	02/18/2013	ND	15.89	24.95	ND	664.84	664.84
	02/19/2013	ND	15.97	NA	ND	664.76	664.76
	05/20/2013	ND	15.75	24.95	ND	664.98	664.98
	05/21/2013	ND	15.59	NA	ND	665.14	665.14
	08/19/2013	ND	15.75	24.97	ND	664.98	664.98
	08/20/2013	ND	15.58	NA	ND	665.15	665.15
	11/04/2013	ND	15.66	25.00	ND	665.07	665.07
	11/07/2013	ND	15.49	NA	ND	665.24	665.24

Notes:
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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	*Date*	*Depth to SPL(ft)*	*Depth to Water (ft)*	*Depth to Bottom (ft)*	*SPL Thickness(ft)*	*Groundwater Elevation (ft)*	*Corrected GW Elevation (ft)*
MW-38R [24.51, 14.51-24.21]							
	03/10/2014	ND	16.13	25.00	ND	664.60	664.60
	05/19/2014	ND	14.70	25.00	ND	666.03	666.03
	05/20/2014	ND	14.80	NA	ND	665.93	665.93
	06/01/2015	ND	15.63	25.00	ND	665.10	665.10
	05/31/2016	ND	15.72	24.80	ND	665.01	665.01
	06/05/2017	ND	16.03	24.80	ND	664.70	664.70
	06/04/2018	ND	15.06	25.00	ND	665.67	665.67
MW-39 [30.53, 20.53-30.23]							
	11/13/2012	ND	24.37	33.27	ND	664.84	664.84
	11/14/2012	ND	24.21	NA	ND	665.00	665.00
	02/18/2013	ND	24.40	33.40	ND	664.81	664.81
	05/20/2013	ND	24.18	33.40	ND	665.03	665.03
	08/19/2013	ND	24.33	33.40	ND	664.88	664.88
	11/04/2013	ND	24.27	33.33	ND	664.94	664.94
	11/05/2013	ND	24.12	NA	ND	665.09	665.09
	03/10/2014	ND	24.71	33.33	ND	664.50	664.50
	05/19/2014	ND	23.29	33.33	ND	665.92	665.92
	06/01/2015	ND	23.99	33.33	ND	665.22	665.22
	05/31/2016	ND	24.20	33.45	ND	665.01	665.01
	06/05/2017	ND	24.91	33.45	ND	664.30	664.30
	06/04/2018	ND	24.62	33.45	ND	664.59	664.59
MW-40 [29.45, 19.45-29.15]							
	11/13/2012	ND	23.59	32.40	ND	664.92	664.92
	11/14/2012	ND	23.43	NA	ND	665.08	665.08
	02/18/2013	ND	23.64	32.37	ND	664.87	664.87
	05/20/2013	ND	23.41	32.37	ND	665.10	665.10
	08/19/2013	ND	23.54	32.37	ND	664.97	664.97
	11/04/2013	ND	23.57	32.45	ND	664.94	664.94
	11/05/2013	ND	23.42	NA	ND	665.09	665.09
	03/10/2014	ND	24.00	32.45	ND	664.51	664.51
	05/19/2014	ND	22.55	32.45	ND	665.96	665.96
	06/01/2015	ND	23.21	32.45	ND	665.30	665.30

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
MW-40 [29.45, 19.45-29.15]							
	05/31/2016	ND	23.51	37.47	ND	665.00	665.00
	06/05/2017	ND	24.19	37.47	ND	664.32	664.32
	06/04/2018	ND	23.90	37.47	ND	664.61	664.61
MW-41 [25.34, 15.34-25.04]							
	11/13/2012	16.02	17.10	23.60	1.08	663.85	664.64
	02/18/2013	15.78	17.53	22.90	1.75	663.42	664.70
	05/20/2013	15.72	16.90	22.90	1.18	664.05	664.91
	08/19/2013	15.75	17.42	22.90	1.67	663.53	664.75
	11/04/2013	15.66	17.27	22.70	1.61	663.68	664.86
	03/10/2014	16.10	17.77	22.70	1.67	663.18	664.40
	05/19/2014	14.72	15.76	22.70	1.04	665.19	665.95
	06/01/2015	15.48	16.78	22.70	1.30	664.17	665.12
	05/31/2016	15.72	16.79	NA	1.07	664.16	664.94
	06/05/2017	15.99	18.10	NA	2.11	662.85	664.39
	06/04/2018	15.97	17.52	25.47	1.55	663.43	664.56
MW-42 [23.53, 13.53-23.23]							
	11/13/2012	ND	15.56	23.10	ND	664.79	664.79
	11/14/2012	ND	15.44	NA	ND	664.91	664.91
	02/18/2013	ND	15.57	23.10	ND	664.78	664.78
	05/20/2013	ND	15.43	23.10	ND	664.92	664.92
	08/19/2013	ND	15.42	23.08	ND	664.93	664.93
	11/04/2013	ND	15.35	23.12	ND	665.00	665.00
	11/07/2013	ND	15.20	NA	ND	665.15	665.15
	03/10/2014	ND	15.81	23.12	ND	664.54	664.54
	05/19/2014	ND	14.33	23.12	ND	666.02	666.02
	05/20/2014	ND	14.46	NA	ND	665.89	665.89
	06/01/2015	ND	15.29	23.12	ND	665.06	665.06
	05/31/2016	ND	15.37	23.10	ND	664.98	664.98
	06/05/2017	ND	15.70	23.10	ND	664.65	664.65
	06/04/2018	ND	15.63	23.08	ND	664.72	664.72
MW-43 [23.54, 13.54-23.24]							
	11/13/2012	ND	15.43	23.68	ND	664.78	664.78

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
MW-43 [23.54, 13.54-23.24]							
	11/14/2012	ND	15.13	NA	ND	665.08	665.08
	02/18/2013	ND	15.44	23.70	ND	664.77	664.77
	05/20/2013	ND	15.31	23.70	ND	664.90	664.90
	05/21/2013	ND	15.08	NA	ND	665.13	665.13
	08/19/2013	ND	15.25	23.66	ND	664.96	664.96
	08/20/2013	ND	15.15	NA	ND	665.06	665.06
	11/04/2013	ND	15.17	23.67	ND	665.04	665.04
	11/07/2013	ND	15.27	NA	ND	664.94	664.94
	03/10/2014	ND	15.64	23.67	ND	664.57	664.57
	05/19/2014	ND	14.21	23.67	ND	666.00	666.00
	05/20/2014	ND	14.33	NA	ND	665.88	665.88
	06/01/2015	ND	15.19	23.67	ND	665.02	665.02
	05/31/2016	ND	15.33	23.66	ND	664.88	664.88
	06/05/2017	ND	15.38	23.66	ND	664.83	664.83
	06/04/2018	ND	15.44	23.66	ND	664.77	664.77
MW-44 [23.77, 13.77-23.47]							
	11/13/2012	ND	15.54	22.45	ND	664.80	664.80
	11/14/2012	ND	15.41	NA	ND	664.93	664.93
	02/18/2013	ND	15.44	23.45	ND	664.90	664.90
	02/19/2013	ND	15.55	NA	ND	664.79	664.79
	05/20/2013	ND	15.41	23.45	ND	664.93	664.93
	08/19/2013	ND	15.39	23.45	ND	664.95	664.95
	08/20/2013	ND	15.26	NA	ND	665.08	665.08
	11/04/2013	ND	15.32	23.44	ND	665.02	665.02
	11/06/2013	ND	15.29	NA	ND	665.05	665.05
	03/10/2014	ND	15.77	23.44	ND	664.57	664.57
	05/19/2014	ND	14.32	23.44	ND	666.02	666.02
	06/01/2015	ND	15.18	23.44	ND	665.16	665.16
	05/31/2016	ND	15.36	23.47	ND	664.98	664.98
	06/05/2017	ND	15.63	23.47	ND	664.71	664.71
	06/04/2018	ND	15.60	23.47	ND	664.74	664.74

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
MW-45 [23.2, 13.2-22.9]							
	11/13/2012	15.34	16.32	23.45	0.98	663.99	664.71
	02/18/2013	15.43	15.94	23.50	0.51	664.37	664.74
	05/20/2013	15.33	15.53	23.50	0.20	664.78	664.93
	08/19/2013	15.28	16.16	23.50	0.88	664.15	664.79
	11/04/2013	15.21	15.72	23.48	0.51	664.59	664.96
	03/10/2014	15.60	15.78	23.48	0.18	664.53	664.66
	05/19/2014	ND	14.31	23.48	ND	666.00	666.00
	06/01/2015	15.11	15.28	23.48	0.17	665.03	665.15
	05/31/2016	15.26	15.76	NA	0.50	664.55	664.92
	06/05/2017	15.59	15.76	NA	0.17	664.55	664.67
	06/04/2018	15.66	16.02	23.38	0.36	664.29	664.55
NW-1							
	05/31/2016	ND	18.80	47.10	ND	665.77	665.77
	06/05/2017	ND	32.15	47.10	ND	652.42	652.42
	06/04/2018	Well Not Gauged - Could not locate; well has been abandoned					
NW-2 [67.29, NA]							
	11/13/2012	ND	21.99	69.69	ND	664.85	664.85
	02/18/2013	ND	22.04	70.90	ND	664.80	664.80
	05/20/2013	ND	21.66	70.90	ND	665.18	665.18
	08/19/2013	ND	22.57	70.90	ND	664.27	664.27
	11/04/2013	ND	22.19	69.25	ND	664.65	664.65
	03/10/2014	ND	22.67	69.25	ND	664.17	664.17
	05/19/2014	ND	21.49	69.25	ND	665.35	665.35
	06/01/2015	ND	21.83	69.25	ND	665.01	665.01
	05/31/2016	ND	22.33	72.70	ND	664.51	664.51
	06/05/2017	ND	23.27	72.70	ND	663.57	663.57
	06/04/2018	ND	22.83	72.70	ND	664.01	664.01
NW-3 [65.36, NA]							
	11/13/2012	ND	22.11	66.90	ND	664.99	664.99
	02/18/2013	ND	21.21	67.00	ND	665.89	665.89
	05/20/2013	ND	21.90	67.00	ND	665.20	665.20
	08/19/2013	ND	22.20	67.00	ND	664.90	664.90

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	*Date*	*Depth to SPL(ft)*	*Depth to Water (ft)*	*Depth to Bottom (ft)*	*SPL Thickness(ft)*	*Groundwater Elevation (ft)*	*Corrected GW Elevation (ft)*
NW-3 [65.36, NA]							
	11/04/2013	ND	23.89	69.30	ND	663.21	663.21
	03/10/2014	ND	24.71	69.30	ND	662.39	662.39
	05/19/2014	ND	23.33	69.30	ND	663.77	663.77
	06/01/2015	ND	23.91	69.30	ND	663.19	663.19
	05/31/2016	ND	24.37	70.40	ND	662.73	662.73
	06/05/2017	ND	25.64	70.40	ND	661.46	661.46
	06/04/2018	ND	25.43	70.40	ND	661.67	661.67
NW-4 [73.62, NA]							
	11/13/2012	ND	23.20	75.00	ND	663.66	663.66
	02/18/2013	ND	23.28	76.50	ND	663.58	663.58
	05/20/2013	ND	22.25	76.50	ND	664.61	664.61
	08/19/2013	ND	24.68	76.50	ND	662.18	662.18
	11/04/2013	Well Not Gauged - Well Inaccessible					
	03/10/2014	ND	22.29	NA	ND	664.57	664.57
	05/19/2014	ND	22.63	NA	ND	664.23	664.23
	06/01/2015	ND	21.45	NA	ND	665.41	665.41
	05/31/2016	ND	23.60	80.05	ND	663.26	663.26
	06/05/2017	ND	25.00	80.05	ND	661.86	661.86
	06/04/2018	ND	22.38	80.05	ND	664.48	664.48
NW-5							
	05/31/2016	ND	46.25	67.50	ND	644.22	644.22
	06/05/2017	ND	24.34	67.50	ND	666.13	666.13
	06/04/2018	ND	24.61	67.50	ND	665.86	665.86
OW-3 [66.889, NA]							
	11/13/2012	ND	17.63	68.90	ND	664.87	664.87
	02/18/2013	ND	17.65	68.90	ND	664.85	664.85
	05/20/2013	ND	17.40	68.90	ND	665.10	665.10
	08/19/2013	ND	17.62	68.90	ND	664.88	664.88
	11/04/2013	ND	17.46	69.05	ND	665.04	665.04
	03/10/2014	ND	17.85	69.05	ND	664.65	664.65
	05/19/2014	ND	16.50	69.05	ND	666.00	666.00
	06/01/2015	ND	17.22	69.05	ND	665.28	665.28

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
OW-3 [66.889, NA]							
	05/31/2016	ND	17.38	70.11	ND	665.12	665.12
	06/05/2017	ND	18.07	70.11	ND	664.43	664.43
	06/04/2018	ND	17.69	70.11	ND	664.81	664.81
PZ-1 [25.263, 10.263-24.963]							
	11/13/2012	ND	17.33	26.95	ND	665.01	665.01
	11/15/2012	ND	17.32	NA	ND	665.02	665.02
	02/18/2013	ND	17.35	26.95	ND	664.99	664.99
	05/20/2013	ND	17.22	26.95	ND	665.12	665.12
	08/19/2013	ND	17.27	26.95	ND	665.07	665.07
	11/04/2013	ND	17.21	26.97	ND	665.13	665.13
	11/05/2013	ND	17.11	NA	ND	665.23	665.23
	03/10/2014	ND	17.66	26.97	ND	664.68	664.68
	05/19/2014	ND	16.13	26.97	ND	666.21	666.21
	06/01/2015	ND	16.98	26.97	ND	665.36	665.36
	05/31/2016	ND	17.22	26.95	ND	665.12	665.12
	06/05/2017	ND	17.66	26.95	ND	664.68	664.68
	06/04/2018	ND	17.50	26.95	ND	664.84	664.84
PZ-2 [26.13, 11.13-25.83]							
	11/13/2012	ND	17.87	28.97	ND	664.99	664.99
	02/18/2013	ND	17.84	28.98	ND	665.02	665.02
	05/20/2013	ND	17.75	28.98	ND	665.11	665.11
	08/19/2013	ND	17.78	28.98	ND	665.08	665.08
	11/04/2013	ND	17.75	29.15	ND	665.11	665.11
	03/10/2014	ND	18.18	29.15	ND	664.68	664.68
	05/19/2014	ND	16.67	29.15	ND	666.19	666.19
	06/01/2015	ND	17.62	29.15	ND	665.24	665.24
	05/31/2016	ND	17.77	29.00	ND	665.09	665.09
	06/05/2017	ND	18.25	29.00	ND	664.61	664.61
	06/04/2018	ND	18.08	29.00	ND	664.78	664.78
PZ-2D [38.976, 28.976-38.676]							
	11/13/2012	ND	16.82	41.10	ND	665.00	665.00
	02/18/2013	ND	16.79	41.20	ND	665.03	665.03

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
PZ-2D [38.976, 28.976-38.676]							
	05/20/2013	ND	16.70	41.20	ND	665.12	665.12
	08/19/2013	ND	16.74	41.20	ND	665.08	665.08
	11/04/2013	ND	16.70	41.05	ND	665.12	665.12
	03/10/2014	ND	17.13	41.05	ND	664.69	664.69
	05/19/2014	ND	15.62	41.05	ND	666.20	666.20
	06/01/2015	ND	16.55	41.05	ND	665.27	665.27
	05/31/2016	ND	16.71	41.15	ND	665.11	665.11
	06/05/2017	ND	17.21	41.15	ND	664.61	664.61
	06/04/2018	ND	17.02	41.15	ND	664.80	664.80
PZ-3 [27.055, 12.055-26.755]							
	11/13/2012	ND	17.85	29.15	ND	664.92	664.92
	11/15/2012	ND	17.80	NA	ND	664.97	664.97
	02/18/2013	ND	17.83	29.97	ND	664.94	664.94
	05/20/2013	ND	17.69	29.97	ND	665.08	665.08
	08/19/2013	ND	17.68	29.97	ND	665.09	665.09
	11/04/2013	ND	17.68	29.30	ND	665.09	665.09
	11/05/2013	ND	17.57	NA	ND	665.20	665.20
	03/10/2014	ND	18.12	29.30	ND	664.65	664.65
	05/19/2014	ND	16.59	29.30	ND	666.18	666.18
	06/01/2015	ND	17.42	29.30	ND	665.35	665.35
	05/31/2016	ND	17.66	28.97	ND	665.11	665.11
	06/05/2017	ND	18.06	28.97	ND	664.71	664.71
	06/04/2018	ND	17.87	28.97	ND	664.90	664.90
PZ-4 [27.132, 12.132-26.832]							
	11/13/2012	ND	17.46	28.20	ND	664.92	664.92
	11/15/2012	ND	17.50	NA	ND	664.88	664.88
	02/18/2013	ND	17.45	28.00	ND	664.93	664.93
	05/20/2013	ND	17.30	28.00	ND	665.08	665.08
	08/19/2013	ND	16.39	28.00	ND	665.99	665.99
	11/04/2013	ND	17.32	28.03	ND	665.06	665.06
	11/06/2013	ND	17.28	NA	ND	665.10	665.10
	03/10/2014	ND	17.79	28.03	ND	664.59	664.59

Notes:
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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
PZ-4 [27.132, 12.132-26.832]							
	05/19/2014	ND	16.29	28.03	ND	666.09	666.09
	06/01/2015	ND	17.15	28.03	ND	665.23	665.23
	05/31/2016	ND	17.35	28.22	ND	665.03	665.03
	06/05/2017	ND	17.85	28.22	ND	664.53	664.53
	06/04/2018	ND	17.62	28.20	ND	664.76	664.76
PZ-5 [26.143, 11.143-25.843]							
	11/13/2012	ND	17.55	28.00	ND	664.98	664.98
	02/18/2013	ND	17.57	28.01	ND	664.96	664.96
	05/20/2013	ND	17.39	28.01	ND	665.14	665.14
	08/19/2013	ND	17.45	28.01	ND	665.08	665.08
	11/04/2013	ND	17.38	28.00	ND	665.15	665.15
	03/10/2014	ND	17.82	28.00	ND	664.71	664.71
	05/19/2014	ND	16.37	28.00	ND	666.16	666.16
	06/01/2015	ND	17.14	28.00	ND	665.39	665.39
	05/31/2016	ND	17.21	28.08	ND	665.32	665.32
	06/05/2017	ND	17.72	28.08	ND	664.81	664.81
	06/04/2018	ND	17.59	28.08	ND	664.94	664.94
PZ-6 [27.234, 12.234-26.934]							
	11/13/2012	ND	18.07	28.62	ND	664.81	664.81
	11/14/2012	ND	17.88	NA	ND	665.00	665.00
	02/18/2013	ND	18.05	28.85	ND	664.83	664.83
	05/20/2013	ND	17.89	28.85	ND	664.99	664.99
	08/19/2013	ND	17.91	28.85	ND	664.97	664.97
	11/04/2013	ND	17.86	28.63	ND	665.02	665.02
	11/06/2013	ND	17.82	NA	ND	665.06	665.06
	03/10/2014	ND	18.29	28.63	ND	664.59	664.59
	05/19/2014	ND	16.86	28.63	ND	666.02	666.02
	06/01/2015	ND	17.58	28.63	ND	665.30	665.30
	05/31/2016	ND	17.85	23.65	ND	665.03	665.03
	06/05/2017	ND	18.23	23.65	ND	664.65	664.65
	06/04/2018	ND	18.06	23.65	ND	664.82	664.82

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
PZ-7 [26.114, 11.114-25.814]							
	11/13/2012	ND	17.29	27.99	ND	664.90	664.90
	02/18/2013	ND	17.29	27.88	ND	664.90	664.90
	05/20/2013	ND	17.14	27.88	ND	665.05	665.05
	08/19/2013	ND	17.19	27.88	ND	665.00	665.00
	11/04/2013	ND	17.12	27.87	ND	665.07	665.07
	03/10/2014	ND	17.52	27.87	ND	664.67	664.67
	05/19/2014	ND	16.14	27.87	ND	666.05	666.05
	06/01/2015	ND	16.98	27.87	ND	665.21	665.21
	05/31/2016	ND	17.08	28.07	ND	665.11	665.11
	06/05/2017	ND	17.52	28.07	ND	664.67	664.67
	06/04/2018	ND	17.34	28.07	ND	664.85	664.85
PZ-8 [26.316, 11.316-26.016]							
	11/13/2012	ND	17.45	28.00	ND	664.87	664.87
	02/18/2013	ND	17.47	28.03	ND	664.85	664.85
	05/20/2013	ND	16.26	28.03	ND	666.06	666.06
	08/19/2013	ND	17.35	28.03	ND	664.97	664.97
	11/04/2013	ND	17.25	28.02	ND	665.07	665.07
	03/10/2014	ND	17.68	28.02	ND	664.64	664.64
	05/19/2014	ND	16.26	28.02	ND	666.06	666.06
	06/01/2015	ND	17.05	28.02	ND	665.27	665.27
	05/31/2016	ND	17.21	28.08	ND	665.11	665.11
	06/05/2017	ND	17.74	28.08	ND	664.58	664.58
	06/04/2018	ND	17.47	28.08	ND	664.85	664.85
PZ-9 [26.377, 11.377-26.077]							
	11/13/2012	ND	17.61	28.27	ND	664.85	664.85
	11/14/2012	ND	17.65	NA	ND	664.81	664.81
	02/18/2013	ND	17.61	28.30	ND	664.85	664.85
	05/20/2013	ND	17.41	28.30	ND	665.05	665.05
	08/19/2013	ND	17.50	28.30	ND	664.96	664.96
	11/04/2013	ND	17.44	28.25	ND	665.02	665.02
	11/06/2013	ND	17.35	NA	ND	665.11	665.11
	03/10/2014	ND	17.84	28.25	ND	664.62	664.62

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
PZ-9 [26.377, 11.377-26.077]							
	05/19/2014	ND	16.45	28.25	ND	666.01	666.01
	06/01/2015	ND	17.09	28.25	ND	665.37	665.37
	05/31/2016	ND	17.39	28.25	ND	665.07	665.07
	06/05/2017	ND	17.86	28.25	ND	664.60	664.60
	06/04/2018	ND	17.56	28.25	ND	664.90	664.90
PZ-10 [25.653, 10.653-25.353]							
	11/13/2012	ND	17.73	27.22	ND	664.96	664.96
	11/15/2012	ND	17.79	NA	ND	664.90	664.90
	02/18/2013	ND	17.75	27.02	ND	664.94	664.94
	02/19/2013	ND	17.91	NA	ND	664.78	664.78
	05/20/2013	ND	17.58	27.02	ND	665.11	665.11
	05/21/2013	ND	17.44	NA	ND	665.25	665.25
	08/19/2013	ND	17.70	27.20	ND	664.99	664.99
	11/04/2013	ND	17.64	27.20	ND	665.05	665.05
	11/06/2013	ND	17.60	NA	ND	665.09	665.09
	03/10/2014	ND	18.07	27.20	ND	664.62	664.62
	05/19/2014	ND	16.53	27.20	ND	666.16	666.16
	06/01/2015	ND	17.43	27.20	ND	665.26	665.26
	05/31/2016	ND	17.64	27.20	ND	665.05	665.05
	06/05/2017	ND	18.21	27.20	ND	664.48	664.48
	06/04/2018	ND	18.01	27.57	ND	664.68	664.68
PZ-11 [26.386, 11.386-26.086]							
	11/13/2012	ND	17.60	28.00	ND	664.97	664.97
	02/18/2013	ND	17.62	28.05	ND	664.95	664.95
	05/20/2013	ND	17.46	28.05	ND	665.11	665.11
	08/19/2013	ND	17.51	28.05	ND	665.06	665.06
	11/04/2013	ND	17.48	28.04	ND	665.09	665.09
	03/10/2014	ND	17.92	28.04	ND	664.65	664.65
	05/19/2014	ND	16.38	28.04	ND	666.19	666.19
	06/01/2015	ND	17.35	28.04	ND	665.22	665.22
	05/31/2016	ND	17.51	28.09	ND	665.06	665.06
	06/05/2017	ND	18.00	28.09	ND	664.57	664.57

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
PZ-11 [26.386, 11.386-26.086]							
	06/04/2018	ND	17.82	28.09	ND	664.75	664.75
PZ-12 [26.265, 11.265-25.965]							
	11/13/2012	ND	18.12	27.97	ND	664.97	664.97
	02/18/2013	ND	18.10	27.95	ND	664.99	664.99
	05/20/2013	ND	17.97	27.95	ND	665.12	665.12
	08/19/2013	ND	18.05	27.95	ND	665.04	665.04
	11/04/2013	ND	17.97	27.98	ND	665.12	665.12
	03/10/2014	ND	18.42	27.98	ND	664.67	664.67
	05/19/2014	ND	16.93	27.98	ND	666.16	666.16
	06/01/2015	ND	17.76	27.98	ND	665.33	665.33
	05/31/2016	ND	17.98	27.95	ND	665.11	665.11
	06/05/2017	ND	18.40	27.95	ND	664.69	664.69
	06/04/2018	ND	18.26	27.95	ND	664.83	664.83
PZ-13 [25.721, 10.721-25.421]							
	11/13/2012	ND	19.07	28.05	ND	664.45	664.45
	11/14/2012	ND	18.79	NA	ND	664.73	664.73
	02/18/2013	ND	19.07	27.98	ND	664.45	664.45
	05/20/2013	ND	18.79	27.98	ND	664.73	664.73
	08/19/2013	ND	18.96	27.98	ND	664.56	664.56
	11/04/2013	ND	18.80	28.05	ND	664.72	664.72
	11/05/2013	ND	18.61	NA	ND	664.91	664.91
	03/10/2014	ND	19.23	28.05	ND	664.29	664.29
	05/19/2014	ND	17.97	28.05	ND	665.55	665.55
	06/01/2015	ND	18.64	28.05	ND	664.88	664.88
	05/31/2016	ND	18.76	28.25	ND	664.76	664.76
	06/05/2017	ND	19.04	28.25	ND	664.48	664.48
	06/04/2018	ND	19.33	28.17	ND	664.19	664.19
PZ-14R [26.837, 16.837-26.537]							
	11/13/2012	ND	22.48	29.80	ND	664.90	664.90
	02/18/2013	ND	22.37	28.81	ND	665.01	665.01
	05/20/2013	ND	22.28	28.81	ND	665.10	665.10
	08/19/2013	ND	22.33	28.81	ND	665.05	665.05

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	*Date*	*Depth to SPL(ft)*	*Depth to Water (ft)*	*Depth to Bottom (ft)*	*SPL Thickness(ft)*	*Groundwater Elevation (ft)*	*Corrected GW Elevation (ft)*
PZ-14R [26.837, 16.837-26.537]							
	11/04/2013	ND	22.30	22.80	ND	665.08	665.08
	03/10/2014	ND	22.74	22.80	ND	664.64	664.64
	05/19/2014	ND	21.20	22.80	ND	666.18	666.18
	06/01/2015	ND	22.16	22.80	ND	665.22	665.22
	05/31/2016	ND	22.31	29.80	ND	665.07	665.07
	06/05/2017	ND	22.84	29.80	ND	664.54	664.54
	06/04/2018	ND	22.62	29.80	ND	664.76	664.76
PZ-15 [29.636, 14.636-29.336]							
	11/13/2012	ND	22.53	31.60	ND	664.92	664.92
	11/15/2012	ND	22.55	NA	ND	664.90	664.90
	02/18/2013	ND	22.50	31.60	ND	664.95	664.95
	05/20/2013	ND	22.35	31.60	ND	665.10	665.10
	08/19/2013	ND	22.42	31.60	ND	665.03	665.03
	11/04/2013	ND	22.43	31.58	ND	665.02	665.02
	11/05/2013	ND	22.30	NA	ND	665.15	665.15
	03/10/2014	ND	22.86	31.58	ND	664.59	664.59
	05/19/2014	ND	21.34	31.58	ND	666.11	666.11
	06/01/2015	ND	22.23	31.58	ND	665.22	665.22
	05/31/2016	ND	22.43	31.80	ND	665.02	665.02
	06/05/2017	ND	22.96	31.80	ND	664.49	664.49
	06/04/2018	ND	22.74	31.80	ND	664.71	664.71
PZ-17R [29.31, 19.31-29.01]							
	11/13/2012	ND	23.99	31.90	ND	664.85	664.85
	02/18/2013	ND	23.96	31.89	ND	664.88	664.88
	05/20/2013	ND	23.78	31.89	ND	665.06	665.06
	08/19/2013	23.88	23.93	31.89	0.05	664.91	664.95
	11/04/2013	23.86	23.93	31.94	0.07	664.91	664.96
	03/10/2014	24.25	24.56	31.94	0.31	664.28	664.51
	05/19/2014	22.76	23.36	31.94	0.60	665.48	665.92
	06/01/2015	23.45	23.78	31.94	0.33	665.06	665.30
	05/31/2016	23.77	24.26	NA	0.49	664.58	664.94
	06/05/2017	24.30	24.66	NA	0.36	664.18	664.44

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
PZ-17R [29.31, 19.31-29.01]							
	06/04/2018	24.13	24.52	NA	0.39	664.32	664.60
PZ-18 [28.128, 13.128-27.828]							
	11/13/2012	ND	20.20	29.90	ND	664.89	664.89
	02/18/2013	ND	20.21	29.90	ND	664.88	664.88
	05/20/2013	ND	19.99	29.90	ND	665.10	665.10
	08/19/2013	ND	20.14	29.90	ND	664.95	664.95
	11/04/2013	ND	20.06	30.02	ND	665.03	665.03
	03/10/2014	ND	20.47	30.02	ND	664.62	664.62
	05/19/2014	ND	19.08	30.02	ND	666.01	666.01
	06/01/2015	ND	19.82	30.02	ND	665.27	665.27
	05/31/2016	ND	20.03	30.12	ND	665.06	665.06
	06/05/2017	ND	20.18	30.12	ND	664.91	664.91
	06/04/2018	ND	20.43	30.12	ND	664.66	664.66
TW-05 [18.82, 13.82-18.72]							
	11/13/2012	ND	15.90	18.56	ND	664.85	664.85
	02/18/2013	ND	15.97	18.61	ND	664.78	664.78
	05/20/2013	ND	15.82	18.61	ND	664.93	664.93
	08/19/2013	ND	15.87	18.61	ND	664.88	664.88
	11/04/2013	ND	15.82	18.60	ND	664.93	664.93
	03/10/2014	ND	16.24	18.60	ND	664.51	664.51
	05/19/2014	ND	14.72	18.60	ND	666.03	666.03
	06/01/2015	ND	15.58	18.60	ND	665.17	665.17
	05/31/2016	ND	15.82	18.60	ND	664.93	664.93
	06/05/2017	ND	16.25	18.60	ND	664.50	664.50
	06/04/2018	ND	16.08	18.60	ND	664.67	664.67
TW-06 [18.2, 13.2-18.1]							
	11/13/2012	18.81	18.82	21.24	0.01	665.76	665.77
	02/18/2013	ND	18.81	21.56	ND	665.77	665.77
	05/20/2013	18.91	18.92	21.56	0.01	665.66	665.67
	08/19/2013	18.84	18.85	21.56	0.01	665.73	665.74
	11/04/2013	18.69	18.70	21.28	0.01	665.88	665.89
	03/10/2014	19.17	19.18	21.28	0.01	665.40	665.41

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Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
TW-06 [18.2, 13.2-18.1]							
	05/19/2014	17.71	17.72	21.28	0.01	666.86	666.87
	06/01/2015	18.63	18.68	21.28	0.05	665.90	665.94
	05/31/2016	18.83	18.87	21.25	0.04	665.71	665.74
	06/05/2017	14.87	14.89	21.25	0.02	669.69	669.70
	06/04/2018	18.90	19.10	21.25	0.20	665.48	665.63
TW-07 [18.67, 13.67-18.57]							
	11/13/2012	18.54	18.81	21.50	0.27	665.43	665.63
	02/18/2013	18.54	18.88	21.52	0.34	665.36	665.61
	05/20/2013	18.44	18.66	21.52	0.22	665.58	665.74
	08/19/2013	18.49	18.80	21.52	0.31	665.44	665.67
	11/04/2013	18.42	18.71	21.53	0.29	665.53	665.74
	03/10/2014	18.89	19.10	21.53	0.21	665.14	665.29
	05/19/2014	17.39	17.49	21.53	0.10	666.75	666.82
	06/01/2015	18.22	18.25	21.53	0.03	665.99	666.01
	05/31/2016	18.45	18.57	NA	0.12	665.67	665.76
	06/05/2017	18.85	18.88	NA	0.03	665.36	665.38
	06/04/2018	18.73	18.80	21.55	0.07	665.44	665.49
RL-1							
	11/13/2012	ND	20.20	NA	ND	665.34	665.34
	02/18/2013	ND	20.50	NA	ND	665.04	665.04
	05/20/2013	ND	20.10	NA	ND	665.44	665.44
	08/19/2013	ND	20.44	NA	ND	665.10	665.10
	11/04/2013	ND	21.34	NA	ND	664.20	664.20
	03/10/2014	ND	20.67	NA	ND	664.87	664.87
	05/19/2014	ND	19.40	NA	ND	666.14	666.14
	06/01/2015	ND	20.15	NA	ND	665.39	665.39
	05/31/2016	ND	19.80	NA	ND	665.74	665.74
	06/05/2017	ND	21.00	NA	ND	664.54	664.54
	06/04/2018	ND	21.00	NA	ND	664.54	664.54
RL-2							
	11/13/2012	ND	10.59	NA	ND	665.34	665.34
	02/18/2013	ND	10.80	NA	ND	665.13	665.13

Notes:
[Well Depth, Screen Interval] - Feet below ground surface
NC - Not Calculated - Top of casing elevation unknown, unable to calculate groundwater elevation
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NA - Not Available

Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
RL-2							
	05/20/2013	ND	10.20	NA	ND	665.73	665.73
	08/19/2013	ND	11.73	NA	ND	664.20	664.20
	11/04/2013	ND	10.65	NA	ND	665.28	665.28
	03/10/2014	ND	10.91	NA	ND	665.02	665.02
	05/19/2014	ND	9.58	NA	ND	666.35	666.35
	06/01/2015	ND	10.13	NA	ND	665.80	665.80
	05/31/2016	ND	10.17	NA	ND	665.76	665.76
	06/05/2017	ND	11.25	NA	ND	664.68	664.68
	06/04/2018	ND	11.20	NA	ND	664.73	664.73
SCAV-1 [19, 9-18.9]							
	11/13/2012	16.23	16.25	19.85	0.02	664.51	664.52
	02/18/2013	16.15	16.16	19.85	0.01	664.60	664.61
	05/20/2013	15.88	15.92	19.85	0.04	664.84	664.87
	08/19/2013	16.13	16.22	19.85	0.09	664.54	664.61
	11/04/2013	16.01	16.12	27.90	0.11	664.64	664.72
	03/10/2014	16.39	16.47	27.90	0.08	664.29	664.35
	05/19/2014	15.04	15.13	27.90	0.09	665.63	665.70
	06/01/2015	15.63	15.78	27.90	0.15	664.98	665.09
	05/31/2016	15.79	15.86	NA	0.07	664.90	664.95
	06/05/2017	16.12	16.24	NA	0.12	664.52	664.61
	06/04/2018	16.09	16.17	18.42	0.08	664.59	664.65
SCAV-2 [19, 9-18.9]							
	11/13/2012	ND	16.17	19.75	ND	664.55	664.55
	02/18/2013	ND	16.15	19.80	ND	664.57	664.57
	05/20/2013	15.87	15.88	19.80	0.01	664.84	664.85
	08/19/2013	ND	16.12	19.80	ND	664.60	664.60
	11/04/2013	15.99	16.00	27.75	0.01	664.72	664.73
	03/10/2014	ND	16.36	27.75	ND	664.36	664.36
	05/19/2014	ND	15.06	27.75	ND	665.66	665.66
	06/01/2015	ND	15.62	27.75	ND	665.10	665.10
	05/31/2016	15.77	15.78	19.80	0.01	664.94	664.95
	06/05/2017	16.18	16.21	19.80	0.03	664.51	664.53

Notes:
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NA - Not Available

Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
SCAV-2 [19, 9-18.9]							
	06/04/2018	16.12	16.20	19.80	0.08	664.52	664.58
SCAV-3 [19, 9-18.9]							
	11/13/2012	ND	16.13	19.80	ND	664.53	664.53
	02/18/2013	ND	16.13	19.95	ND	664.53	664.53
	05/20/2013	ND	15.83	19.95	ND	664.83	664.83
	08/19/2013	ND	16.09	19.95	ND	664.57	664.57
	11/04/2013	ND	15.93	27.95	ND	664.73	664.73
	03/10/2014	ND	16.32	27.95	ND	664.34	664.34
	05/19/2014	ND	15.02	27.95	ND	665.64	665.64
	06/01/2015	ND	15.60	27.95	ND	665.06	665.06
	05/31/2016	ND	15.73	19.80	ND	664.93	664.93
	06/05/2017	ND	16.21	19.80	ND	664.45	664.45
	06/04/2018	ND	16.23	19.80	ND	664.43	664.43
SCAV-4 [20, 10-19.9]							
	11/13/2012	ND	16.26	18.65	ND	664.92	664.92
	02/18/2013	ND	16.29	18.50	ND	664.89	664.89
	05/20/2013	Well Not Gauged - Unable to access asbestos area		18.50			
	08/19/2013	ND	16.13	18.50	ND	665.05	665.05
	11/04/2013	ND	16.08	18.65	ND	665.10	665.10
	03/10/2014	ND	16.56	18.65	ND	664.62	664.62
	05/19/2014	ND	15.07	18.65	ND	666.11	666.11
	06/01/2015	ND	15.85	18.65	ND	665.33	665.33
	05/31/2016	ND	16.12	18.50	ND	665.06	665.06
	06/05/2017	ND	16.48	18.50	ND	664.70	664.70
	06/04/2018	ND	16.31	18.50	ND	664.87	664.87
SCAV-5 [20, 10-19.9]							
	11/13/2012	ND	16.35	20.10	ND	664.95	664.95
	02/18/2013	ND	16.38	20.08	ND	664.92	664.92
	05/20/2013	ND	16.21	20.08	ND	665.09	665.09
	08/19/2013	ND	16.23	20.08	ND	665.07	665.07
	11/04/2013	ND	16.19	20.15	ND	665.11	665.11
	03/10/2014	ND	16.65	20.15	ND	664.65	664.65

Notes:
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NA - Not Available

Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
SCAV-5 [20, 10-19.9]							
	05/19/2014	ND	15.17	20.15	ND	666.13	666.13
	06/01/2015	ND	15.96	20.15	ND	665.34	665.34
	05/31/2016	ND	16.22	20.00	ND	665.08	665.08
	06/05/2017	ND	16.58	20.00	ND	664.72	664.72
	06/04/2018	ND	16.42	22.00	ND	664.88	664.88
SCAV-6 [20, 10-19.9]							
	11/13/2012	ND	16.42	19.25	ND	664.97	664.97
	02/18/2013	ND	16.46	19.25	ND	664.93	664.93
	05/20/2013	ND	16.29	19.25	ND	665.10	665.10
	08/19/2013	ND	16.29	19.25	ND	665.10	665.10
	11/04/2013	ND	16.28	19.30	ND	665.11	665.11
	03/10/2014	ND	16.73	19.30	ND	664.66	664.66
	05/19/2014	ND	15.22	19.30	ND	666.17	666.17
	06/01/2015	ND	16.04	19.30	ND	665.35	665.35
	05/31/2016	ND	16.32	19.15	ND	665.07	665.07
	06/05/2017	ND	16.67	19.15	ND	664.72	664.72
	06/04/2018	ND	16.48	19.15	ND	664.91	664.91
SCAV-7 [20, 10-19.9]							
	11/13/2012	ND	15.92	18.50	ND	664.95	664.95
	02/18/2013	ND	15.94	19.50	ND	664.93	664.93
	05/20/2013	ND	15.78	19.50	ND	665.09	665.09
	08/19/2013	ND	15.78	19.50	ND	665.09	665.09
	11/04/2013	ND	15.76	18.56	ND	665.11	665.11
	03/10/2014	ND	16.22	18.56	ND	664.65	664.65
	05/19/2014	ND	14.72	18.56	ND	666.15	666.15
	06/01/2015	ND	15.52	18.56	ND	665.35	665.35
	05/31/2016	ND	15.78	18.55	ND	665.09	665.09
	06/05/2017	ND	16.17	18.55	ND	664.70	664.70
	06/04/2018	ND	15.97	18.55	ND	664.90	664.90
SCAV-8 [20, 10-19.9]							
	11/13/2012	ND	14.85	19.55	ND	664.96	664.96
	02/18/2013	ND	14.87	19.55	ND	664.94	664.94

Notes:
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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
SCAV-8 [20, 10-19.9]							
	05/20/2013	ND	14.68	19.55	ND	665.13	665.13
	08/19/2013	ND	14.73	19.55	ND	665.08	665.08
	11/04/2013	ND	14.73	19.65	ND	665.08	665.08
	03/10/2014	ND	15.18	19.65	ND	664.63	664.63
	05/19/2014	ND	13.68	19.65	ND	666.13	666.13
	06/01/2015	ND	14.57	19.65	ND	665.24	665.24
	05/31/2016	ND	14.72	19.55	ND	665.09	665.09
	06/05/2017	ND	15.08	19.55	ND	664.73	664.73
	06/04/2018	ND	14.93	19.55	ND	664.88	664.88
SCAV-9 [20, 10-19.9]							
	11/13/2012	ND	15.70	18.15	ND	664.31	664.31
	02/18/2013	ND	15.70	18.15	ND	664.31	664.31
	05/20/2013	ND	15.52	18.15	ND	664.49	664.49
	08/19/2013	ND	15.63	18.15	ND	664.38	664.38
	11/04/2013	ND	16.57	18.19	ND	663.44	663.44
	03/10/2014	ND	15.98	18.19	ND	664.03	664.03
	05/19/2014	ND	14.92	18.19	ND	665.09	665.09
	06/01/2015	ND	15.39	18.19	ND	664.62	664.62
	05/31/2016	ND	15.57	18.30	ND	664.44	664.44
	06/05/2017	ND	16.08	18.30	ND	663.93	663.93
	06/04/2018	ND	15.84	18.30	ND	664.17	664.17
SCAV-10 [20, 10-19.9]							
	11/13/2012	ND	16.25	19.05	ND	664.85	664.85
	02/18/2013	ND	16.26	19.00	ND	664.84	664.84
	05/20/2013	ND	16.08	19.00	ND	665.02	665.02
	08/19/2013	ND	16.12	19.00	ND	664.98	664.98
	11/04/2013	ND	16.06	19.10	ND	665.04	665.04
	03/10/2014	ND	16.51	19.10	ND	664.59	664.59
	05/19/2014	ND	15.09	19.10	ND	666.01	666.01
	06/01/2015	ND	15.79	19.10	ND	665.31	665.31
	05/31/2016	ND	16.08	19.10	ND	665.02	665.02
	06/05/2017	ND	16.42	19.10	ND	664.68	664.68

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
SCAV-10 [20, 10-19.9]							
	06/04/2018	ND	16.24	19.10	ND	664.86	664.86
SCAV-11 [20, 10-19.9]							
	11/13/2012	ND	16.04	17.05	ND	664.84	664.84
	02/18/2013	ND	16.08	16.80	ND	664.80	664.80
	05/20/2013	ND	15.88	16.80	ND	665.00	665.00
	08/19/2013	ND	15.94	16.80	ND	664.94	664.94
	11/04/2013	ND	15.86	17.05	ND	665.02	665.02
	03/10/2014	ND	16.32	17.05	ND	664.56	664.56
	05/19/2014	ND	14.88	17.05	ND	666.00	666.00
	06/01/2015	ND	15.60	17.05	ND	665.28	665.28
	05/31/2016	ND	15.56	17.05	ND	665.32	665.32
	06/05/2017	ND	16.23	17.05	ND	664.65	664.65
	06/04/2018	ND	16.07	17.05	ND	664.81	664.81
SCAV-12 [20, 10-19.9]							
	11/13/2012	ND	16.49	20.50	ND	664.83	664.83
	02/18/2013	ND	16.51	20.45	ND	664.81	664.81
	05/20/2013	ND	16.33	20.45	ND	664.99	664.99
	08/19/2013	ND	16.38	20.45	ND	664.94	664.94
	11/04/2013	ND	16.31	20.40	ND	665.01	665.01
	03/10/2014	ND	16.76	20.40	ND	664.56	664.56
	05/19/2014	ND	15.32	20.40	ND	666.00	666.00
	06/01/2015	ND	16.07	20.40	ND	665.25	665.25
	05/31/2016	ND	16.32	20.40	ND	665.00	665.00
	06/05/2017	ND	16.68	20.40	ND	664.64	664.64
	06/04/2018	ND	16.53	20.40	ND	664.79	664.79
SCAV-13 [20, 10-19.9]							
	11/13/2012	ND	16.20	20.70	ND	664.96	664.96
	11/15/2012	ND	16.22	NA	ND	664.94	664.94
	02/18/2013	ND	16.20	20.83	ND	664.96	664.96
	05/20/2013	ND	18.03	20.83	ND	663.13	663.13
	08/19/2013	ND	16.12	20.83	ND	665.04	665.04
	11/04/2013	ND	16.09	20.70	ND	665.07	665.07

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
SCAV-13 [20, 10-19.9]							
	11/06/2013	ND	16.03	NA	ND	665.13	665.13
	03/10/2014	ND	16.50	20.70	ND	664.66	664.66
	05/19/2014	ND	14.98	20.70	ND	666.18	666.18
	06/01/2015	ND	15.91	20.70	ND	665.25	665.25
	05/31/2016	ND	16.11	20.75	ND	665.05	665.05
	06/05/2017	ND	16.60	20.75	ND	664.56	664.56
	06/04/2018	ND	16.32	20.75	ND	664.84	664.84
SCAV-14 [20, 10-19.9]							
	11/13/2012	ND	15.73	20.45	ND	664.91	664.91
	11/15/2012	ND	15.70	NA	ND	664.94	664.94
	02/18/2013	ND	8.75	20.50	ND	671.89	671.89
	05/20/2013	ND	15.62	20.50	ND	665.02	665.02
	08/19/2013	ND	15.53	20.50	ND	665.11	665.11
	11/04/2013	ND	16.51	20.56	ND	664.13	664.13
	11/05/2013	ND	15.66	NA	ND	664.98	664.98
	03/10/2014	ND	16.01	20.56	ND	664.63	664.63
	05/19/2014	ND	14.43	20.56	ND	666.21	666.21
	06/01/2015	ND	15.46	20.56	ND	665.18	665.18
	05/31/2016	ND	15.82	20.46	ND	664.82	664.82
	06/05/2017	ND	15.86	20.46	ND	664.78	664.78
	06/04/2018	ND	15.82	20.46	ND	664.82	664.82
SCAV-15 [20, 10-19.9]							
	11/13/2012	ND	16.43	18.48	ND	664.95	664.95
	02/18/2013	ND	16.45	18.60	ND	664.93	664.93
	05/20/2013	ND	16.20	18.60	ND	665.18	665.18
	08/19/2013	ND	16.42	18.60	ND	664.96	664.96
	11/04/2013	ND	16.36	18.57	ND	665.02	665.02
	03/10/2014	ND	16.78	18.57	ND	664.60	664.60
	05/19/2014	ND	15.21	18.57	ND	666.17	666.17
	06/01/2015	ND	16.08	18.57	ND	665.30	665.30
	05/31/2016	ND	16.32	18.37	ND	665.06	665.06
	06/05/2017	ND	16.84	18.37	ND	664.54	664.54

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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
SCAV-15 [20, 10-19.9]							
	06/04/2018	ND	16.70	18.37	ND	664.68	664.68
SCAV-16 [20, 10-19.9]							
	11/13/2012	ND	16.73	22.15	ND	664.96	664.96
	02/18/2013	ND	16.79	22.20	ND	664.90	664.90
	05/20/2013	ND	16.81	22.20	ND	664.88	664.88
	08/19/2013	ND	16.69	22.20	ND	665.00	665.00
	11/04/2013	ND	16.53	22.12	ND	665.16	665.16
	03/10/2014	ND	17.09	22.12	ND	664.60	664.60
	05/19/2014	ND	15.66	22.12	ND	666.03	666.03
	06/01/2015	ND	16.67	22.12	ND	665.02	665.02
	05/31/2016	ND	16.75	NA	ND	664.94	664.94
	06/05/2017	ND	16.89	NA	ND	664.80	664.80
	06/04/2018	ND	16.96	21.55	ND	664.73	664.73
SCAV-17 [22.89, 12.89-22.79]							
	11/13/2012	ND	14.81	22.00	ND	664.90	664.90
	02/18/2013	ND	14.82	22.05	ND	664.89	664.89
	05/20/2013	ND	14.69	22.05	ND	665.02	665.02
	08/19/2013	ND	14.75	22.05	ND	664.96	664.96
	11/04/2013	ND	14.61	22.05	ND	665.10	665.10
	03/10/2014	ND	15.09	22.05	ND	664.62	664.62
	05/19/2014	ND	13.89	22.05	ND	665.82	665.82
	06/01/2015	ND	14.60	22.05	ND	665.11	665.11
	05/31/2016	14.70	14.72	22.00	0.02	664.99	665.00
	06/05/2017	ND	14.89	22.00	ND	664.82	664.82
	06/04/2018	ND	15.94	22.00	ND	663.77	663.77
SCAV-18 [23, 13-22.9]							
	11/13/2012	ND	14.62	22.00	ND	665.01	665.01
	02/18/2013	ND	14.61	22.03	ND	665.02	665.02
	05/20/2013	ND	14.62	22.03	ND	665.01	665.01
	08/19/2013	ND	14.56	22.03	ND	665.07	665.07
	11/04/2013	ND	14.45	22.08	ND	665.18	665.18
	03/10/2014	ND	14.83	22.08	ND	664.80	664.80

Notes:
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Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
SCAV-18 [23, 13-22.9]							
	05/19/2014	ND	13.49	22.08	ND	666.14	666.14
	06/01/2015	ND	14.40	22.08	ND	665.23	665.23
	05/31/2016	ND	14.61	22.00	ND	665.02	665.02
	06/05/2017	ND	14.68	22.00	ND	664.95	664.95
	06/04/2018	ND	14.72	22.00	ND	664.91	664.91
SCAV-19 [22, 12-21.9]							
	11/13/2012	14.46	14.63	21.05	0.17	664.76	664.88
	02/18/2013	14.47	14.92	21.03	0.45	664.47	664.80
	05/20/2013	14.33	14.43	21.03	0.10	664.96	665.03
	08/19/2013	14.37	14.49	21.03	0.12	664.90	664.99
	11/04/2013	14.28	14.39	21.10	0.11	665.00	665.08
	03/10/2014	14.72	14.79	21.10	0.07	664.60	664.65
	05/19/2014	13.25	13.46	21.10	0.21	665.93	666.08
	06/01/2015	14.09	14.33	21.10	0.24	665.06	665.24
	05/31/2016	14.29	14.49	NA	0.20	664.90	665.05
	06/05/2017	14.60	14.77	NA	0.17	664.62	664.74
	06/04/2018	14.60	14.76	21.05	0.16	664.63	664.75
SCAV-20 [23.097, 13.097-22.797]							
	11/13/2012	ND	18.96	25.32	ND	664.77	664.77
	11/15/2012	ND	18.95	NA	ND	664.78	664.78
	02/18/2013	ND	18.95	25.32	ND	664.78	664.78
	05/20/2013	ND	18.77	25.32	ND	664.96	664.96
	08/19/2013	ND	18.84	25.32	ND	664.89	664.89
	11/04/2013	ND	18.72	25.29	ND	665.01	665.01
	11/06/2013	ND	18.71	NA	ND	665.02	665.02
	03/10/2014	ND	19.14	25.29	ND	664.59	664.59
	05/19/2014	ND	17.74	25.29	ND	665.99	665.99
	06/01/2015	ND	18.58	25.29	ND	665.15	665.15
	05/31/2016	ND	18.66	25.35	ND	665.07	665.07
	06/05/2017	ND	19.10	25.35	ND	664.63	664.63
	06/04/2018	ND	19.00	25.29	ND	664.73	664.73

Notes:
[Well Depth, Screen Interval] - Feet below ground surface
NC - Not Calculated - Top of casing elevation unknown, unable to calculate groundwater elevation
ND - Not Detected
NM - Not Measurable
NA - Not Available

Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
SCAV-21 [23.607, 13.607-23.307]							
	11/13/2012	ND	19.11	26.15	ND	664.82	664.82
	11/16/2012	ND	19.04	NA	ND	664.89	664.89
	02/18/2013	ND	19.12	26.10	ND	664.81	664.81
	02/19/2013	ND	19.27	NA	ND	664.66	664.66
	05/20/2013	ND	18.89	26.10	ND	665.04	665.04
	05/21/2013	ND	18.71	NA	ND	665.22	665.22
	08/19/2013	ND	19.02	26.10	ND	664.91	664.91
	11/04/2013	ND	18.89	26.05	ND	665.04	665.04
	11/06/2013	ND	18.87	NA	ND	665.06	665.06
	03/10/2014	ND	19.30	26.05	ND	664.63	664.63
	05/19/2014	ND	17.94	26.05	ND	665.99	665.99
	05/20/2014	ND	18.15	NA	ND	665.78	665.78
	06/01/2015	ND	18.71	26.05	ND	665.22	665.22
	05/31/2016	ND	18.77	26.14	ND	665.16	665.16
	06/05/2017	ND	19.31	26.14	ND	664.62	664.62
	06/04/2018	ND	19.13	26.14	ND	664.80	664.80
SCAV-22 [23.679, 13.679-23.379]							
	11/13/2012	18.01	18.03	25.10	0.02	664.87	664.88
	02/18/2013	ND	18.07	25.10	ND	664.83	664.83
	05/20/2013	17.83	17.88	25.10	0.05	665.02	665.06
	08/19/2013	17.92	18.09	25.10	0.17	664.81	664.93
	11/04/2013	17.85	17.97	26.08	0.12	664.93	665.02
	03/10/2014	18.27	18.38	26.08	0.11	664.52	664.60
	05/19/2014	16.85	17.06	26.08	0.21	665.84	665.99
	06/01/2015	17.48	17.65	26.08	0.17	665.25	665.37
	05/31/2016	17.75	18.17	NA	0.42	664.73	665.04
	06/05/2017	18.28	18.57	NA	0.29	664.33	664.54
	06/04/2018	18.01	18.21	25.10	0.20	664.69	664.84
SCAV-23 [22.532, 12.532-22.232]							
	11/13/2012	ND	17.99	25.55	ND	664.89	664.89
	02/18/2013	ND	18.05	25.70	ND	664.83	664.83
	05/20/2013	ND	17.85	25.70	ND	665.03	665.03

Notes:
[Well Depth, Screen Interval] - Feet below ground surface
NC - Not Calculated - Top of casing elevation unknown, unable to calculate groundwater elevation
ND - Not Detected
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NA - Not Available

Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	*Date*	*Depth to SPL(ft)*	*Depth to Water (ft)*	*Depth to Bottom (ft)*	*SPL Thickness(ft)*	*Groundwater Elevation (ft)*	*Corrected GW Elevation (ft)*
SCAV-23 [22.532, 12.532-22.232]							
	08/19/2013	ND	17.90	25.70	ND	664.98	664.98
	11/04/2013	ND	17.85	25.60	ND	665.03	665.03
	03/10/2014	18.29	18.30	25.60	0.01	664.58	664.59
	05/19/2014	ND	16.83	25.60	ND	666.05	666.05
	06/01/2015	17.53	17.55	25.60	0.02	665.33	665.34
	05/31/2016	17.84	17.87	NA	0.03	665.01	665.03
	06/05/2017	ND	18.26	NA	ND	664.62	664.62
	06/04/2018	ND	18.03	25.52	ND	664.85	664.85
SCAV-24 [24.83, 14.83-24.53]							
	11/13/2012	ND	15.12	24.55	ND	664.99	664.99
	02/18/2013	ND	15.13	24.30	ND	664.98	664.98
	05/20/2013	ND	15.02	24.30	ND	665.09	665.09
	08/19/2013	ND	15.09	24.30	ND	665.02	665.02
	11/04/2013	ND	15.01	24.40	ND	665.10	665.10
	03/10/2014	ND	15.51	24.40	ND	664.60	664.60
	05/19/2014	ND	13.98	24.40	ND	666.13	666.13
	06/01/2015	ND	14.85	24.40	ND	665.26	665.26
	05/31/2016	ND	15.10	24.30	ND	665.01	665.01
	06/05/2017	ND	15.53	24.30	ND	664.58	664.58
	06/04/2018	ND	15.41	24.30	ND	664.70	664.70
SCAV-25 [24.56, 14.56-24.26]							
	11/13/2012	ND	15.26	24.50	ND	664.94	664.94
	02/18/2013	ND	15.26	24.35	ND	664.94	664.94
	05/20/2013	ND	15.14	24.35	ND	665.06	665.06
	08/19/2013	ND	15.20	24.35	ND	665.00	665.00
	11/04/2013	ND	15.14	24.30	ND	665.06	665.06
	03/10/2014	ND	15.61	24.30	ND	664.59	664.59
	05/19/2014	ND	14.10	24.30	ND	666.10	666.10
	06/01/2015	ND	14.93	24.30	ND	665.27	665.27
	05/31/2016	ND	15.17	24.20	ND	665.03	665.03
	06/05/2017	ND	15.62	24.20	ND	664.58	664.58
	06/04/2018	ND	15.47	24.20	ND	664.73	664.73

Notes:
[Well Depth, Screen Interval] - Feet below ground surface
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NA - Not Available

Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
SCAV-26 [24, 14-23.7]							
	11/13/2012	ND	15.50	23.75	ND	664.98	664.98
	02/18/2013	15.49	15.51	23.70	0.02	664.97	664.98
	05/20/2013	15.35	15.47	23.70	0.12	665.01	665.10
	08/19/2013	15.44	15.57	23.70	0.13	664.91	665.00
	11/04/2013	15.36	15.47	23.46	0.11	665.01	665.09
	03/10/2014	15.81	16.06	23.46	0.25	664.42	664.60
	05/19/2014	14.33	14.56	23.46	0.23	665.92	666.09
	06/01/2015	15.14	15.36	23.46	0.22	665.12	665.28
	05/31/2016	15.36	15.66	NA	0.30	664.82	665.04
	06/05/2017	15.78	15.79	NA	0.01	664.69	664.70
	06/04/2018	15.70	15.79	23.70	0.09	664.69	664.76
SCAV-27 [23.033, 13.033-22.733]							
	11/13/2012	ND	14.42	22.02	ND	664.83	664.83
	02/18/2013	ND	14.41	22.00	ND	664.84	664.84
	05/20/2013	ND	14.24	22.00	ND	665.01	665.01
	08/19/2013	ND	14.25	22.00	ND	665.00	665.00
	11/04/2013	ND	14.19	22.01	ND	665.06	665.06
	03/10/2014	ND	14.63	22.01	ND	664.62	664.62
	05/19/2014	ND	13.11	22.01	ND	666.14	666.14
	06/01/2015	ND	14.06	22.01	ND	665.19	665.19
	05/31/2016	ND	14.16	22.08	ND	665.09	665.09
	06/05/2017	ND	14.60	22.08	ND	664.65	664.65
	06/04/2018	ND	14.43	22.08	ND	664.82	664.82
SCAV-28 [29.23, 19.23-28.93]							
	11/13/2012	ND	20.46	27.80	ND	665.62	665.62
	02/18/2013	ND	20.36	27.65	ND	665.72	665.72
	05/20/2013	ND	20.22	27.65	ND	665.86	665.86
	08/19/2013	ND	20.34	27.65	ND	665.74	665.74
	11/04/2013	20.31	20.32	27.58	0.01	665.76	665.77
	03/10/2014	20.74	20.75	27.58	0.01	665.33	665.34
	05/19/2014	19.29	19.34	27.58	0.05	666.74	666.78
	06/01/2015	19.93	19.97	27.58	0.04	666.11	666.14

Notes:
[Well Depth, Screen Interval] - Feet below ground surface
NC - Not Calculated - Top of casing elevation unknown, unable to calculate groundwater elevation
ND - Not Detected
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NA - Not Available

Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	*Date*	*Depth to SPL(ft)*	*Depth to Water (ft)*	*Depth to Bottom (ft)*	*SPL Thickness(ft)*	*Groundwater Elevation (ft)*	*Corrected GW Elevation (ft)*
SCAV-28 [29.23, 19.23-28.93]							
	05/31/2016	20.27	20.30	NA	0.03	665.78	665.80
	06/05/2017	ND	24.78	NA	ND	661.30	661.30
	06/04/2018	20.61	20.62	29.30	0.01	665.46	665.47
SCAV-29 [26.62, 16.62-26.32]							
	11/13/2012	14.93	15.44	21.50	0.51	665.01	665.38
	02/18/2013	14.94	15.40	21.92	0.46	665.05	665.39
	05/20/2013	14.82	15.25	21.92	0.43	665.20	665.51
	08/19/2013	14.89	15.43	21.92	0.54	665.02	665.41
	11/04/2013	14.79	15.42	21.70	0.63	665.03	665.49
	03/10/2014	15.24	15.79	21.70	0.55	664.66	665.06
	05/19/2014	13.78	14.37	21.70	0.59	666.08	666.51
	06/01/2015	14.58	14.92	21.70	0.34	665.53	665.78
	05/31/2016	14.78	15.42	NA	0.64	665.03	665.50
	06/05/2017	15.21	15.63	NA	0.42	664.82	665.13
	06/04/2018	15.17	15.81	26.14	0.64	664.64	665.11
SCAV-30 [26.76, 16.76-26.46]							
	11/13/2012	15.05	15.06	21.70	0.01	665.79	665.80
	02/18/2013	15.04	15.05	21.70	0.01	665.80	665.81
	05/20/2013	Well Not Gauged - Covered by equipment		21.70			
	08/19/2013	ND	15.00	21.70	ND	665.85	665.85
	11/04/2013	14.91	14.93	21.63	0.02	665.92	665.93
	03/10/2014	ND	15.36	21.63	ND	665.49	665.49
	05/19/2014	ND	13.91	21.63	ND	666.94	666.94
	06/01/2015	ND	14.70	21.63	ND	666.15	666.15
	05/31/2016	14.89	14.91	NA	0.02	665.94	665.95
	06/05/2017	15.22	15.24	NA	0.02	665.61	665.62
	06/04/2018	ND	15.21	25.38	ND	665.64	665.64
SCAV-31 [26.21, 16.21-25.91]							
	11/13/2012	ND	14.42	22.15	ND	664.86	664.86
	02/18/2013	ND	15.32	22.20	ND	663.96	663.96
	05/20/2013	ND	14.32	22.20	ND	664.96	664.96
	08/19/2013	ND	15.27	22.20	ND	664.01	664.01

Notes:
[Well Depth, Screen Interval] - Feet below ground surface
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ND - Not Detected
NM - Not Measurable
NA - Not Available

Table B-1
Groundwater Elevation and SPL Thickness Data
Former Quaker State/Ergon Refinery, Newell, WV

Well	Date	Depth to SPL(ft)	Depth to Water (ft)	Depth to Bottom (ft)	SPL Thickness(ft)	Groundwater Elevation (ft)	Corrected GW Elevation (ft)
SCAV-31 [26.21, 16.21-25.91]							
	11/04/2013	ND	14.24	22.15	ND	665.04	665.04
	03/10/2014	ND	14.71	22.15	ND	664.57	664.57
	05/19/2014	ND	13.24	22.15	ND	666.04	666.04
	06/01/2015	ND	14.11	22.15	ND	665.17	665.17
	05/31/2016	ND	14.29	27.10	ND	664.99	664.99
	06/05/2017	ND	14.59	27.10	ND	664.69	664.69
	06/04/2018	ND	14.53	27.10	ND	664.75	664.75

Notes:
[Well Depth, Screen Interval] - Feet below ground surface
NC - Not Calculated - Top of casing elevation unknown, unable to calculate groundwater elevation
ND - Not Detected
NM - Not Measurable
NA - Not Available

Table B-2
Groundwater Data Summary Sampled Wells
Former Quaker State/Ergon Refinery, Newell, WV

Well and Sample Date	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	MTBE (µg/L)	MEK (µg/L)	Arsenic (µg/L)
Screening Level	*MCL - 5*	*MCL - 1,000*	*MCL - 700*	*MCL - 10,000*	*RSL - 14*	*RSL - 560*	*MCL - 10*
GM-3D							
11/14/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	0.99 J	NS	NS
11/05/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	0.77 J	NS	NS
06/02/2015	ND(0.5)	ND(1.0)	ND(1.0)	ND(1.0)	0.51 J	NS	1.30
06/01/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/06/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/05/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
GM-10							
11/14/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	1.60	NS	NS
11/06/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	2.90	NS	NS
GM-11							
11/15/2012	0.79 J	0.86 J	ND(1.0)	ND(1.0)	6.00	NS	NS
11/06/2013	0.32 J	0.73 J	ND(1.0)	0.32 J	6.50	NS	NS
MW-1							
11/14/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
11/05/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
MW-3							
11/14/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
11/05/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
06/02/2015	ND(0.5)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	ND(1.0)
06/01/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/06/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/05/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
MW-3 DUP							
11/05/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
06/02/2015	ND(0.5)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	ND(1.0)
MW-4							
11/15/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	1.60	NS	NS
11/06/2013	ND(1.0)	0.53 J	ND(1.0)	ND(1.0)	0.29 J	NS	NS
06/02/2015	ND(0.5)	ND(1.0)	ND(1.0)	ND(1.0)	0.42 J	NS	3.80
06/01/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	7.40
06/06/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	**20.9**
06/07/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	**18.0**
MW-5							
02/21/2012	ND(500)	**200000**	ND(500)	ND(500)	ND(500)	ND(5000)	NS
05/22/2012	ND(500)	**296000**	ND(500)	ND(500)	ND(500)	ND(5000)	NS

Notes:

(µg/L) - micrograms per Liter
ND (0.01) - Not Detected with reporting limit
NS - Not Sampled

9.63 B,x - Result with validation flag and reason code
f - field duplicate imprecision
J - Estimated value

MCL- Maximum Containment Level
RSL- Regional Screening Level - May 2019
Exceeds screening level

Table B-2
Groundwater Data Summary Sampled Wells
Former Quaker State/Ergon Refinery, Newell, WV

Well and Sample Date	*Benzene (µg/L)*	*Toluene (µg/L)*	*Ethylbenzene (µg/L)*	*Total Xylenes (µg/L)*	*MTBE (µg/L)*	*MEK (µg/L)*	*Arsenic (µg/L)*
Screening Level	*MCL - 5*	*MCL - 1,000*	*MCL - 700*	*MCL - 10,000*	*RSL - 14*	*RSL - 560*	*MCL - 10*
MW-7							
11/15/2012	**104**	9.10	3.90	14.6	2.30	NS	NS
11/06/2013	**62.8**	6.10	1.90	12.9	1.50	NS	NS
MW-7 DUP							
11/15/2012	**100**	9.20	3.70	14.2	2.20	NS	NS
MW-8							
11/15/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	0.77 J	NS	NS
11/05/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	1.40	NS	NS
MW-9							
06/06/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	5.58
MW-10							
11/14/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	1.90	NS	NS
11/06/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	1.60	NS	NS
MW-13R							
06/04/2015	ND(0.5)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	6.50
06/02/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	4.96
06/08/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	6.72
06/06/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	9.31
MW-22							
11/14/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
11/05/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
MW-24							
11/14/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
11/05/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
06/02/2015	ND(0.5)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	ND(1.0)
06/01/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/06/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/05/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
MW-26D							
11/13/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	2.20	NS	NS
11/06/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
MW-26E							
11/13/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	1.10	NS	NS
11/06/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	0.68 J	NS	NS
06/03/2015	ND(0.5)	ND(1.0)	ND(1.0)	ND(1.0)	0.51 J	NS	ND(1.0)
06/01/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)

Notes:

(µg/L) - micrograms per Liter
ND (0.01) - Not Detected with reporting limit
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9.63 B,x - Result with validation flag and reason code
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Former Quaker State/Ergon Refinery, Newell, WV

Well and Sample Date	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	MTBE (µg/L)	MEK (µg/L)	Arsenic (µg/L)
Screening Level	*MCL - 5*	*MCL - 1,000*	*MCL - 700*	*MCL - 10,000*	*RSL - 14*	*RSL - 560*	*MCL - 10*
MW-26E							
06/06/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/05/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
MW-26S							
11/13/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
11/05/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
MW-29							
06/04/2015	0.89	0.91 J B,x	0.36 J	0.89 J	1.40	NS	**20.3**
06/02/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	**23.0**
06/07/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	**19.9**
06/05/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	**32.8**
MW-29 DUP							
06/02/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	**22.4**
MW-31							
02/21/2012	**75.4**	2.20 J	ND(10)	ND(10)	**22.9**	ND(100)	NS
08/16/2012	**68.4**	1.40	0.99 J	2.70	**21.3**	ND(10)	NS
11/16/2012	**88.0**	7.90	1.30	3.20	**24.8**	ND(10)	NS
02/19/2013	**103**	1.70	1.20	2.90	**26.8**	ND(10)	NS
05/21/2013	**72.3**	2.20	1.30	2.70	**25.9**	ND(10)	NS
08/20/2013	**84.8**	1.30	1.50	2.60	**22.7**	ND(10)	NS
11/07/2013	**52.3**	1.40	1.10	2.50	**20.0**	ND(10)	NS
06/04/2015	**54.2**	1.90	0.84 J	3.70	12.7	ND(10)	**52.7**
06/01/2016	**16.4**	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	ND(5.0)	**59.8**
06/08/2017	**49.7**	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	ND(5.0)	**64.1**
06/07/2018	**28.5**	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	ND(5.0)	**64.2**
MW-31 DUP							
11/07/2013	**52.2**	1.40	1.20	2.60	**21.1**	ND(10)	NS
06/04/2015	**52.8**	1.80	0.74 J	3.50	12.2	ND(10)	**52.7**
06/01/2016	**15.3 J,f**	ND(5.0)	ND(5.0)	ND(10)	6.83	ND(5.0)	**61.0**
MW-38R							
08/16/2012	ND(5000)	**314000**	ND(5000)	ND(5000)	ND(5000)	**1530000**	NS
11/16/2012	ND(5000)	**405000**	ND(5000)	ND(5000)	ND(5000)	**1060000**	NS
02/19/2013	ND(2000)	**391000**	ND(2000)	ND(2000)	ND(2000)	**1270000**	NS
05/21/2013	ND(2000)	**431000**	ND(2000)	ND(2000)	ND(2000)	**1120000**	NS
08/20/2013	ND(2000)	**358000**	ND(2000)	ND(2000)	ND(2000)	**680000 B,x**	NS
11/07/2013	ND(2000)	**351000**	ND(2000)	ND(2000)	ND(2000)	**722000**	NS

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Well and Sample Date	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	MTBE (µg/L)	MEK (µg/L)	Arsenic (µg/L)
Screening Level	MCL - 5	MCL - 1,000	MCL - 700	MCL - 10,000	RSL - 14	RSL - 560	MCL - 10
MW-38R							
03/11/2014	ND(2000)	**451000**	ND(2000)	ND(4000)	ND(4000)	**529000**	NS
05/20/2014	ND(1000)	**386000**	ND(2000)	ND(2000)	ND(2000)	**599000**	NS
06/03/2015	ND(1300)	**392000**	ND(2500)	ND(2500)	ND(2500)	ND(25000)	**37.1**
06/02/2016	ND(50000)	**428000**	ND(50000)	ND(100000)	ND(50000)	**57200**	**30.2**
06/07/2017	ND(12500)	**262000**	ND(12500)	ND(25000)	ND(12500)	**110000**	**36.1**
06/07/2018	ND(10000)	**332000**	ND(10000)	ND(20000)	ND(10000)	**45700**	**44.1**
MW-39							
11/14/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
11/05/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
06/02/2015	ND(0.5)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	ND(1.0)
06/01/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/06/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/05/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
MW-40							
11/14/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
11/05/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
06/06/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
MW-42							
02/21/2012	ND(200)	**64400**	ND(200)	ND(200)	ND(200)	ND(2000)	NS
05/21/2012	ND(5.0)	**3150**	ND(5.0)	ND(5.0)	ND(5.0)	ND(50)	NS
08/15/2012	ND(1.0)	355	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
08/23/2012	NS	NS	NS	NS	NS	NS	NS
11/14/2012	ND(1.0)	2.70	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
02/18/2013	ND(1.0)	155	ND(1.0)	0.55 J	ND(1.0)	ND(10)	NS
05/20/2013	ND(1.0)	0.91 J	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
08/19/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
11/07/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
03/10/2014	ND(5.0)	**1380**	ND(5.0)	ND(10)	ND(10)	ND(100)	NS
05/20/2014	ND(0.5)	0.81 J B,x	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
06/03/2015	ND(13)	**3830 J-,m**	ND(25)	ND(25)	ND(25)	ND(250)	9.80 J,s
06/02/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	ND(5.0)	**14.1**
06/06/2017	ND(250)	**1340**	ND(250)	ND(500)	ND(250)	**3200**	**15.3**
06/06/2018	ND(5.0)	**1520**	ND(5.0)	ND(10)	ND(5.0)	386	**15.4**
MW-42 DUP							
05/20/2014	ND(0.5)	0.41 J B,x	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS

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Well and Sample Date	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	MTBE (µg/L)	MEK (µg/L)	Arsenic (µg/L)
Screening Level	*MCL - 5*	*MCL - 1,000*	*MCL - 700*	*MCL - 10,000*	*RSL - 14*	*RSL - 560*	*MCL - 10*
MW-43							
02/21/2012	ND(20)	**11000**	ND(20)	ND(20)	ND(20)	ND(200)	NS
05/22/2012	ND(500)	**50800**	ND(500)	ND(500)	ND(500)	**95900**	NS
08/15/2012	ND(20)	**29000**	ND(20)	ND(20)	ND(20)	**29900**	NS
11/14/2012	ND(200)	**91200**	ND(200)	ND(200)	ND(200)	**177000**	NS
02/18/2013	ND(500)	**63000**	ND(500)	ND(500)	ND(500)	**394000**	NS
05/21/2013	ND(1000)	**64500**	ND(1000)	ND(1000)	ND(1000)	**432000**	NS
08/20/2013	ND(250)	**48900**	247 J	547	ND(250)	**379000**	NS
11/07/2013	ND(1000)	**53800**	ND(1000)	ND(1000)	ND(1000)	**1330000**	NS
03/11/2014	ND(500)	**84300**	ND(500)	ND(1000)	ND(1000)	**1680000**	NS
05/20/2014	ND(25)	**11300**	ND(50)	ND(50)	ND(50)	**78000**	NS
06/03/2015	ND(250)	**89300**	ND(500)	ND(500)	ND(500)	**29000 J,c**	**45.2**
06/02/2016	ND(500)	**4150**	ND(500)	ND(1000)	ND(500)	ND(500)	**41.0**
06/07/2017	ND(200)	**5280 J+,m**	ND(200)	ND(400)	ND(200)	441	**52.9**
06/07/2018	ND(250)	**13700**	ND(500)	ND(1000)	ND(500)	ND(500)	**56.7**
MW-43 DUP							
08/15/2012	ND(200)	**28600**	ND(200)	ND(200)	ND(200)	**31500**	NS
MW-44							
02/21/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
05/22/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
08/16/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
11/14/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
02/19/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
05/20/2013	ND(1.0)	1.70 B,z	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
08/20/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
11/06/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
03/10/2014	ND(0.5)	ND(1.0)	ND(0.5)	ND(1.0)	ND(1.0)	ND(10)	NS
05/19/2014	ND(0.5)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
MW-44 DUP							
08/20/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(10)	NS
PZ-1							
11/15/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
11/05/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
PZ-3							
11/15/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
11/05/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS

Notes:

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Well and Sample Date	*Benzene (µg/L)*	*Toluene (µg/L)*	*Ethylbenzene (µg/L)*	*Total Xylenes (µg/L)*	*MTBE (µg/L)*	*MEK (µg/L)*	*Arsenic (µg/L)*
Screening Level	*MCL - 5*	*MCL - 1,000*	*MCL - 700*	*MCL - 10,000*	*RSL - 14*	*RSL - 560*	*MCL - 10*
PZ-4							
11/15/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	0.56 J	NS	NS
11/06/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	0.55 J	NS	NS
06/03/2015	ND(0.5)	ND(1.0)	ND(1.0)	ND(1.0)	0.48 J	NS	2.00
06/02/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	1.32
06/08/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	2.72
06/06/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	2.56
PZ-6							
11/14/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	1.50	NS	NS
11/06/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	1.60	NS	NS
PZ-9							
11/15/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	0.96 J	NS	NS
11/06/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
PZ-10							
02/21/2012	ND(1.0)	0.21 J	1.60	0.59 J	0.54 J	NS	NS
05/22/2012	ND(1.0)	ND(1.0)	ND(1.0)	0.22 J	0.37 J	NS	NS
08/16/2012	ND(1.0)	0.38 J	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
11/15/2012	ND(1.0)	0.23 J	0.36 J	0.43 J	ND(1.0)	NS	NS
02/19/2013	ND(1.0)	ND(1.0)	0.99 J	0.41 J	0.62 J	NS	NS
05/21/2013	ND(1.0)	ND(1.0)	ND(1.0)	0.34 J	ND(1.0)	NS	NS
08/19/2013	ND(1.0)	0.25 J	ND(1.0)	0.52 J	0.52 J	NS	NS
11/06/2013	ND(1.0)	ND(1.0)	ND(1.0)	0.46 J	0.99 J	NS	NS
03/11/2014	ND(0.5)	ND(1.0)	ND(0.5)	0.46 J	0.63 J K,m	NS	NS
05/19/2014	ND(0.5)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
06/03/2015	ND(0.5)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	2.40
06/02/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/07/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/05/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	2.79
PZ-10 DUP							
02/21/2012	ND(1.0)	0.22 J	1.70	0.67 J	0.57 J	NS	NS
05/22/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	0.36 J	NS	NS
11/15/2012	ND(1.0)	0.24 J	0.36 J	0.59 J	0.61 J	NS	NS
11/06/2013	ND(1.0)	ND(1.0)	ND(1.0)	0.50 J	1.10	NS	NS
PZ-13							
11/14/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
11/05/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS

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Screening Level	*MCL - 5*	*MCL - 1,000*	*MCL - 700*	*MCL - 10,000*	*RSL - 14*	*RSL - 560*	*MCL - 10*
PZ-13							
06/02/2015	ND(0.5)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	1.10
06/02/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/06/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/05/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
PZ-15							
11/15/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
11/05/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
06/02/2015	ND(0.5)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	ND(1.0)
06/01/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/07/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/05/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
SCAV-5							
06/03/2015	1.00	0.30 J B,x	ND(1.0)	0.48 J	ND(1.0)	ND(10)	6.90 J,s
06/01/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	1.99
06/06/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	2.92
06/06/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	5.05
SCAV-8							
06/02/2015	ND(0.5)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	3.20
06/01/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	ND(1.0)
06/06/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	3.41
SCAV-13							
11/15/2012	0.31 J	0.39 J	5.70	0.51 J	ND(1.0)	NS	NS
11/06/2013	0.48 J	ND(1.0)	7.70	0.79 J	ND(1.0)	NS	NS
06/03/2015	0.55	0.33 J B,x	4.40	0.50 J	ND(1.0)	NS	**17.3**
06/02/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	**10.2**
06/07/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	**14.7**
06/05/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	**14.3**
SCAV-13 DUP							
11/15/2012	0.30 J	0.35 J	5.10	0.77 J	ND(1.0)	NS	NS
11/06/2013	0.45 J	ND(1.0)	8.40	0.85 J	ND(1.0)	NS	NS
06/03/2015	0.55	0.36 J B,x	5.20	0.50 J	ND(1.0)	NS	**19.1**
SCAV-14							
11/15/2012	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS
11/05/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	NS	NS

Notes:

(µg/L) - micrograms per Liter
ND (0.01) - Not Detected with reporting limit
NS - Not Sampled

9.63 B,x - Result with validation flag and reason code
f - field duplicate imprecision
J - Estimated value

MCL- Maximum Containment Level
RSL- Regional Screening Level - May 2019
Exceeds screening level

Table B-2
Groundwater Data Summary Sampled Wells
Former Quaker State/Ergon Refinery, Newell, WV

Well and Sample Date	*Benzene (µg/L)*	*Toluene (µg/L)*	*Ethylbenzene (µg/L)*	*Total Xylenes (µg/L)*	*MTBE (µg/L)*	*MEK (µg/L)*	*Arsenic (µg/L)*
Screening Level	*MCL - 5*	*MCL - 1,000*	*MCL - 700*	*MCL - 10,000*	*RSL - 14*	*RSL - 560*	*MCL - 10*
SCAV-16							
06/02/2015	ND(2.5)	554	ND(5.0)	ND(5.0)	ND(5.0)	ND(50)	**32.9**
06/02/2016	ND(50)	467	ND(50)	ND(100)	ND(50)	ND(50)	**21.9**
06/07/2017	ND(5.0)	127 J,m	ND(5.0)	ND(10)	ND(5.0)	ND(5.0)	**21.5**
06/06/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	ND(5.0)	**29.7**
SCAV-17							
06/02/2015	ND(0.5)	0.59 J	ND(1.0)	ND(1.0)	0.59 J	NS	**21.9**
06/06/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	9.41
06/06/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	**24.4**
SCAV-18							
06/07/2017	**71.8 J+,m**	ND(5.0)	ND(5.0)	ND(10)	10.4	NS	6.16
SCAV-20							
11/15/2012	1.70	0.70 J	0.28 J	0.83 J	ND(1.0)	NS	NS
11/06/2013	0.82 J	0.58 J	0.22 J	0.69 J	0.37 J	NS	NS
06/03/2015	1.10	0.63 J B,x	ND(1.0)	0.66 J	0.39 J	NS	**26.7**
06/03/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	**22.6**
06/08/2017	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	**24.6**
06/06/2018	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	**27.4**
SCAV-20 DUP							
06/03/2016	ND(5.0)	ND(5.0)	ND(5.0)	ND(10)	ND(5.0)	NS	**22.6**
SCAV-21							
02/21/2012	**20.4**	0.34 J	0.32 J	ND(1.0)	7.40	NS	NS
05/22/2012	1.20	ND(1.0)	ND(1.0)	ND(1.0)	4.70	NS	NS
08/16/2012	0.38 J	ND(1.0)	ND(1.0)	ND(1.0)	1.80	NS	NS
11/16/2012	0.25 J	ND(1.0)	ND(1.0)	ND(1.0)	1.20	NS	NS
02/19/2013	1.20	ND(1.0)	ND(1.0)	ND(1.0)	1.60	NS	NS
05/21/2013	0.37 J	ND(1.0)	ND(1.0)	ND(1.0)	1.40	NS	NS
08/19/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	0.91 J	NS	NS
11/06/2013	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	0.58 J	NS	NS
03/11/2014	0.39 J	ND(1.0)	ND(0.5)	0.21 J	2.00	NS	NS
05/20/2014	4.00	ND(1.0)	ND(1.0)	ND(1.0)	1.30	NS	NS
SCAV-21 DUP							
11/16/2012	2.00	2.00	2.00	91.0	1.00	NS	NS
02/19/2013	1.20	ND(1.0)	ND(1.0)	ND(1.0)	1.60	NS	NS
05/21/2013	0.34 J	ND(1.0)	ND(1.0)	ND(1.0)	1.30	NS	NS
03/11/2014	0.36 J	ND(1.0)	ND(0.5)	0.23 J	2.20	NS	NS

Notes:

(µg/L) - micrograms per Liter
ND (0.01) - Not Detected with reporting limit
NS - Not Sampled

9.63 B,x - Result with validation flag and reason code
f - field duplicate imprecision
J - Estimated value

MCL- Maximum Containment Level
RSL- Regional Screening Level - May 2019
Exceeds screening level

Table B-3
Field Parameter Data of Groundwater Samples
Former Quaker State/Ergon Refinery, Newell, WV

Well	Sample Date	Temperature (deg C)	Specific Conductance (uS/cm)	Dissolved Oxygen (mg/L)	PH (SU)	Redox (mV)	Turbidity (NTU)
GM-3D							
	6/2/2015	15.24	0.602	0.80	5.93	118.30	0.57
	6/1/2016	18.59	0.812	1.98	5.70	121.00	0.00
	6/6/2017	16.07	0.731	0.95	5.69	199.90	16.81
	6/5/2018	16.15	0.648	0.62	5.66	86.60	25.21
MW-3							
	6/2/2015	13.15	0.357	1.34	6.68	124.40	0.56
	6/1/2016	16.32	0.351	0.52	6.88	92.00	0.00
	6/6/2017	14.90	0.388	0.96	6.58	189.80	8.65
	6/5/2018	15.86	0.361	0.91	6.58	119.40	1.51
MW-4							
	6/2/2015	17.05	0.966	0.70	6.20	-19.80	1.34
	6/1/2016	20.66	1.380	1.74	6.15	-72.00	0.00
	6/6/2017	18.95	1.421	0.90	6.59	-88.30	4.31
	6/7/2018	17.08	2.615	0.30	6.36	-81.00	9.61
MW-9							
	6/6/2018	14.29	0.604	0.28	6.39	-90.80	8.04
MW-13R							
	6/4/2015	15.06	5.674	0.27	6.71	-49.90	79.30
	6/2/2016	21.69	1.700	0.00	7.46	-169.00	14.70
	6/8/2017	16.05	5.941	0.36	7.02	-131.90	10.20
	6/6/2018	15.14	5.036	0.54	7.26	-131.20	53.10
MW-24							
	6/2/2015	12.54	0.367	6.20	6.24	128.50	0.54
	6/1/2016	17.30	0.333	4.76	6.49	126.00	0.00
	6/6/2017	14.39	0.367	5.80	6.39	232.50	4.72
	6/5/2018	16.70	0.475	6.82	6.24	69.20	5.18
MW-26E							
	6/3/2015	16.05	0.646	0.39	6.40	54.00	0.40
	6/1/2016	22.92	0.685	0.19	6.47	90.00	0.00
	6/6/2017	16.14	0.385	7.47	6.61	234.90	1.36
	6/5/2018	16.52	0.529	6.59	6.48	125.00	4.88
MW-29							
	6/4/2015	14.20	0.686	0.26	6.53	-92.60	2.92
	6/2/2016	15.66	0.709	0.00	6.76	-154.00	0.00
	6/7/2017	14.36	0.678	0.36	6.88	-146.80	4.36
	6/5/2018	18.21	0.668	0.52	6.67	-156.30	5.91
MW-31							

NS - Not Sampled

Table B-3
Field Parameter Data of Groundwater Samples
Former Quaker State/Ergon Refinery, Newell, WV

Well	Sample Date	Temperature (deg C)	Specific Conductance (uS/cm)	Dissolved Oxygen (mg/L)	PH (SU)	Redox (mV)	Turbidity (NTU)
MW-31							
	6/4/2015	17.13	4.040	0.32	6.74	-102.90	1.03
	6/1/2016	19.28	4.020	1.69	6.84	-179.00	0.00
	6/8/2017	16.54	4.114	0.83	6.90	-151.10	16.21
	6/7/2018	16.60	4.004	0.54	6.58	-174.70	0.00
MW-38R							
	6/3/2015	15.45	0.523	0.43	6.43	-80.30	5.03
	6/2/2016	21.11	0.629	1.79	6.58	-126.00	0.00
	6/7/2017	16.03	0.706	0.89	6.52	-90.90	31.63
	6/7/2018	15.62	0.862	0.87	6.10	-116.50	38.21
MW-39							
	6/2/2015	13.51	0.808	4.73	5.93	162.90	0.52
	6/1/2016	19.35	0.845	2.87	5.83	176.00	4.20
	6/6/2017	15.71	0.464	4.03	5.99	267.70	18.52
	6/5/2018	15.12	1.421	3.87	5.56	189.20	7.76
MW-40							
	6/6/2017	13.97	0.357	3.96	6.23	158.70	2.39
MW-42							
	6/3/2015	16.00	1.563	0.39	6.73	-105.10	7.63
	6/2/2016	17.43	2.750	2.14	6.89	-178.00	0.00
	6/6/2017	16.22	3.231	0.87	6.86	-147.70	5.66
	6/6/2018	15.54	2.223	0.34	7.01	-165.30	11.63
MW-43							
	6/3/2015	17.04	0.788	0.24	6.69	118.90	15.60
	6/2/2016	17.41	0.798	2.04	6.90	-186.00	0.00
	6/7/2017	16.98	0.958	1.02	6.86	-141.60	14.33
	6/7/2018	15.88	1.096	0.64	6.58	-172.20	5.71
PZ-4							
	6/3/2015	14.37	1.346	0.37	6.46	-41.90	2.44
	6/2/2016	15.64	1.180	0.00	6.50	-89.00	0.00
	6/8/2017	14.43	1.013	0.48	6.58	-97.50	3.49
	6/6/2018	13.71	1.276	0.57	6.52	-102.10	3.50
PZ-10							
	6/3/2015	16.83	0.644	0.26	6.72	-74.80	0.57
	6/2/2016	19.44	0.608	0.00	7.16	-178.00	0.00
	6/7/2017	16.75	0.588	0.38	7.24	-163.80	2.20
	6/5/2018	15.24	2.313	0.28	6.68	-108.10	3.67
PZ-13							

NS - Not Sampled

Table B-3
Field Parameter Data of Groundwater Samples
Former Quaker State/Ergon Refinery, Newell, WV

Well	Sample Date	Temperature (deg C)	Specific Conductance (uS/cm)	Dissolved Oxygen (mg/L)	PH (SU)	Redox (mV)	Turbidity (NTU)
PZ-13							
	6/2/2015	15.38	3.873	0.42	4.96	233.70	0.43
	6/2/2016	17.69	3.790	0.17	5.24	296.00	2.50
	6/6/2017	15.85	3.924	0.56	5.48	195.40	1.46
	6/5/2018	16.51	3.658	0.50	5.56	114.00	3.50
PZ-15							
	6/2/2015	12.64	0.485	0.70	5.73	161.20	0.42
	6/1/2016	18.42	0.509	0.00	5.70	186.00	3.10
	6/7/2017	13.21	0.484	0.49	5.71	193.40	2.61
	6/5/2018	16.90	0.461	0.75	5.65	142.70	1.31
SCAV-5							
	6/3/2015	14.48	1.325	0.30	6.86	-121.80	5.26
	6/1/2016	21.77	1.240	1.61	6.68	-138.00	1.70
	6/6/2017	15.95	1.658	0.90	6.60	-78.20	6.60
	6/6/2018	14.43	2.369	0.29	7.54	-205.40	1.19
SCAV-8							
	6/2/2015	14.15	0.395	0.39	6.20	23.80	14.80
	6/1/2016	20.95	0.440	1.66	6.32	-60.00	0.00
	6/6/2017	15.85	0.398	0.90	6.68	-72.30	3.30
SCAV-13							
	6/3/2015	16.90	0.722	0.55	6.24	-59.40	3.38
	6/2/2016	19.85	0.746	0.17	6.48	-115.00	0.80
	6/7/2017	17.32	0.459	0.36	6.50	-112.10	8.76
	6/5/2018	15.45	0.485	0.54	6.53	-142.10	2.64
SCAV-16							
	6/2/2015	15.59	1.111	0.44	6.63	-111.80	11.20
	6/2/2016	17.06	1.220	2.28	6.83	-162.00	0.00
	6/7/2017	15.86	1.135	0.94	6.73	-112.10	15.68
	6/6/2018	16.06	1.515	0.49	6.74	-154.70	88.79
SCAV-17							
	6/2/2015	15.85	3.037	0.29	6.73	107.20	5.63
	6/6/2017	17.75	1.763	0.87	6.72	-112.40	11.63
	6/6/2018	16.46	3.025	0.62	6.57	-110.90	3.93
SCAV-18							
	6/7/2017	17.59	3.964	0.88	6.94	-117.80	5.94
SCAV-20							
	6/3/2015	15.27	1.360	0.20	6.45	-56.70	2.79
	6/3/2016	19.04	1.080	0.00	6.66	-125.00	9.20

NS - Not Sampled

Table B-3
Field Parameter Data of Groundwater Samples
Former Quaker State/Ergon Refinery, Newell, WV

Well	*Sample Date*	*Temperature (deg C)*	*Specific Conductance (uS/cm)*	*Dissolved Oxygen (mg/L)*	*PH (SU)*	*Redox (mV)*	*Turbidity (NTU)*
SCAV-20							
	6/8/2017	15.90	0.909	0.36	6.66	-121.20	4.08
	6/6/2018	15.55	1.571	0.61	6.44	-118.50	3.33

NS - Not Sampled

Table B-4
Natural Attenuation Data of Groundwater Samples
Former Quaker State/Ergon Refinery, Newell, WV

Well	*Sample Date*	*Total Alkalinity (mg/L)*	*Total Iron (mg/L)*	*Ferrous Iron (mg/L)*	*Sulfate (mg/L)*	*Nitrate/Nitrate (mg/L)*
GM-3D						
	6/2/2015	86.6	0.05	0.05	138	1.7
	6/1/2016	98.5	0.5	0.1	123	1.66
	6/6/2017	87.6	0	0	116	0.968
	6/5/2018	90.0	0	0	120	1.11
MW-3						
	6/2/2015	57.8	0.1	0	62.5	0.84
	6/1/2016	78.4	0	0	62.2	1.13
	6/6/2017	113	0	0	61.2	1.26
	6/5/2018	98.0	0	0	47.8	1.16
MW-4						
	6/2/2015	126	20	30	127	ND(0.10)
	6/1/2016	205	18	17	110	ND(0.10)
	6/6/2017	269	25	25	40.1	ND(0.10)
	6/7/2018	228	20	20	76.2	ND(0.10)
MW-9						
	6/6/2018	156	85	30	1.47	ND(0.10)
MW-13R						
	6/4/2015	260	6	6	162	ND(0.10)
	6/2/2016	271	2	2	45.6	ND(0.10)
	6/8/2017	458	NS	15	19.9	ND(0.10)
	6/6/2018	348	2	1	123	ND(0.10)
MW-24						
	6/2/2015	36.8	0	0	78.9	1.8
	6/1/2016	62.3	0	0	66.6	2.42
	6/6/2017	67.7	0	0	75.1	2.55
	6/5/2018	62.0	0	0	101	5.68
MW-26E						
	6/3/2015	139	0	0	62.1	ND(0.10)
	6/1/2016	173	0	0	60.1	ND(0.10)
	6/6/2017	71.6	0	0	63.0	0.286
	6/5/2018	94.0	0	0	57.4	0.122
MW-29						
	6/4/2015	131	135	90	ND(10.0)	ND(0.10)

Notes:
(mg/L) - milligrams per Liter
ND (100) - Not Detected (Reporting Limit)
NS - Not Sampled
J - Estimated value
f - field duplicate imprecision

Table B-4
Natural Attenuation Data of Groundwater Samples
Former Quaker State/Ergon Refinery, Newell, WV

Well	Sample Date	Total Alkalinity (mg/L)	Total Iron (mg/L)	Ferrous Iron (mg/L)	Sulfate (mg/L)	Nitrate/Nitrate (mg/L)
MW-29						
	6/2/2016	160	120	90	ND(1.0)	ND(0.10)
	6/7/2017	173	90	90	ND(1.0)	ND(0.10)
	6/5/2018	174	90	60	ND(1.0)	ND(0.10)
MW-31						
	6/4/2015	64.1	135	120	10.0	ND(0.10)
	6/1/2016	96.5	105	80	ND(2.5)	ND(0.10)
	6/8/2017	127	NS	90	3.44	ND(0.10)
	6/7/2018	178	75	60	44.3	ND(0.10)
MW-38R						
	6/3/2015	212	75	60	11.3	ND(0.10)
	6/2/2016	316	90	90	6.26	ND(0.10)
	6/7/2017	376	40	30	2.98	ND(0.10)
	6/7/2018	354	90	30	1.59	ND(0.10)
MW-39						
	6/2/2015	36.2	0	0	64.0	2.7
	6/1/2016	56.3	0	0	74.4	4.34
	6/6/2017	97.5	0	0	41.0	1.45
	6/5/2018	54.0	0	0	44.6	1.85
MW-40						
	6/6/2017	79.6	0	0	58.8	1.03
MW-42						
	6/3/2015	298	75	60	17.5	ND(0.10)
	6/2/2016	342	105	110	16.8	ND(0.10)
	6/6/2017	438	70	65	5.31	ND(0.10)
	6/6/2018	494	75	70	3.64	ND(0.10)
MW-43						
	6/3/2015	305	90	90	ND(10.0)	ND(0.10)
	6/2/2016	353	150	150	ND(1.0)	ND(0.10)
	6/7/2017	444	90	70	ND(1.0)	ND(0.10)
	6/7/2018	406	90	30	ND(1.0)	ND(0.10)
PZ-4						
	6/3/2015	268	45	25	79.9	ND(0.10)
	6/2/2016	400	37	25	39.5	ND(0.10)

Notes:
(mg/L) - milligrams per Liter
ND (100) - Not Detected (Reporting Limit)
NS - Not Sampled
J - Estimated value
f - field duplicate imprecision

Table B-4
Natural Attenuation Data of Groundwater Samples
Former Quaker State/Ergon Refinery, Newell, WV

Well	*Sample Date*	*Total Alkalinity (mg/L)*	*Total Iron (mg/L)*	*Ferrous Iron (mg/L)*	*Sulfate (mg/L)*	*Nitrate/Nitrate (mg/L)*
PZ-4						
	6/8/2017	372	NS	25	51.6	ND(0.10)
	6/6/2018	346	10	10	30.0	ND(0.10)
PZ-10						
	6/3/2015	202	3	3	33.7	ND(0.10)
	6/2/2016	297	2	2	16.6	ND(0.10)
	6/7/2017	283	2	2	14.9	ND(0.10)
	6/5/2018	492	2	2	14.8	ND(0.10)
PZ-13						
	6/2/2015	20.5	0	0	62.5	ND(0.10)
	6/2/2016	39.0	0	0	38.9	ND(0.10)
	6/6/2017	91.5	0	0	34.2	0.177
	6/5/2018	98.0	0	0	39.7	ND(0.10)
PZ-15						
	6/2/2015	52.5	0	0	123	2.3
	6/1/2016	68.3	0	0	120	2.76
	6/7/2017	61.7	0	0	111	2.96
	6/5/2018	58.0	0	0	87.0	3.19
SCAV-5						
	6/3/2015	233	45	30	ND(10.0)	ND(0.10)
	6/1/2016	207	45	26	21.7	ND(0.10)
	6/6/2017	165	30	27	3.07	ND(0.10)
	6/6/2018	356	45	20	1.19	ND(0.10)
SCAV-8						
	6/2/2015	146	11	7.5	30.8	ND(0.10)
	6/1/2016	141	3.5	2	44.5 J,f	1.57 J,f
	6/6/2017	155	30	30	8.58	0.189
SCAV-13						
	6/3/2015	153	135	90	ND(10.0)	ND(0.10)
	6/2/2016	178	90	60	ND(1.0)	ND(0.10)
	6/7/2017	153	30	30	1.72	ND(0.10)
	6/5/2018	120	90	30	ND(1.0)	ND(0.10)
SCAV-16						
	6/2/2015	289	10	6.4	ND(10.0)	ND(0.10)

Notes:

(mg/L) - milligrams per Liter
ND (100) - Not Detected (Reporting Limit)
NS - Not Sampled
J - Estimated value
f - field duplicate imprecision

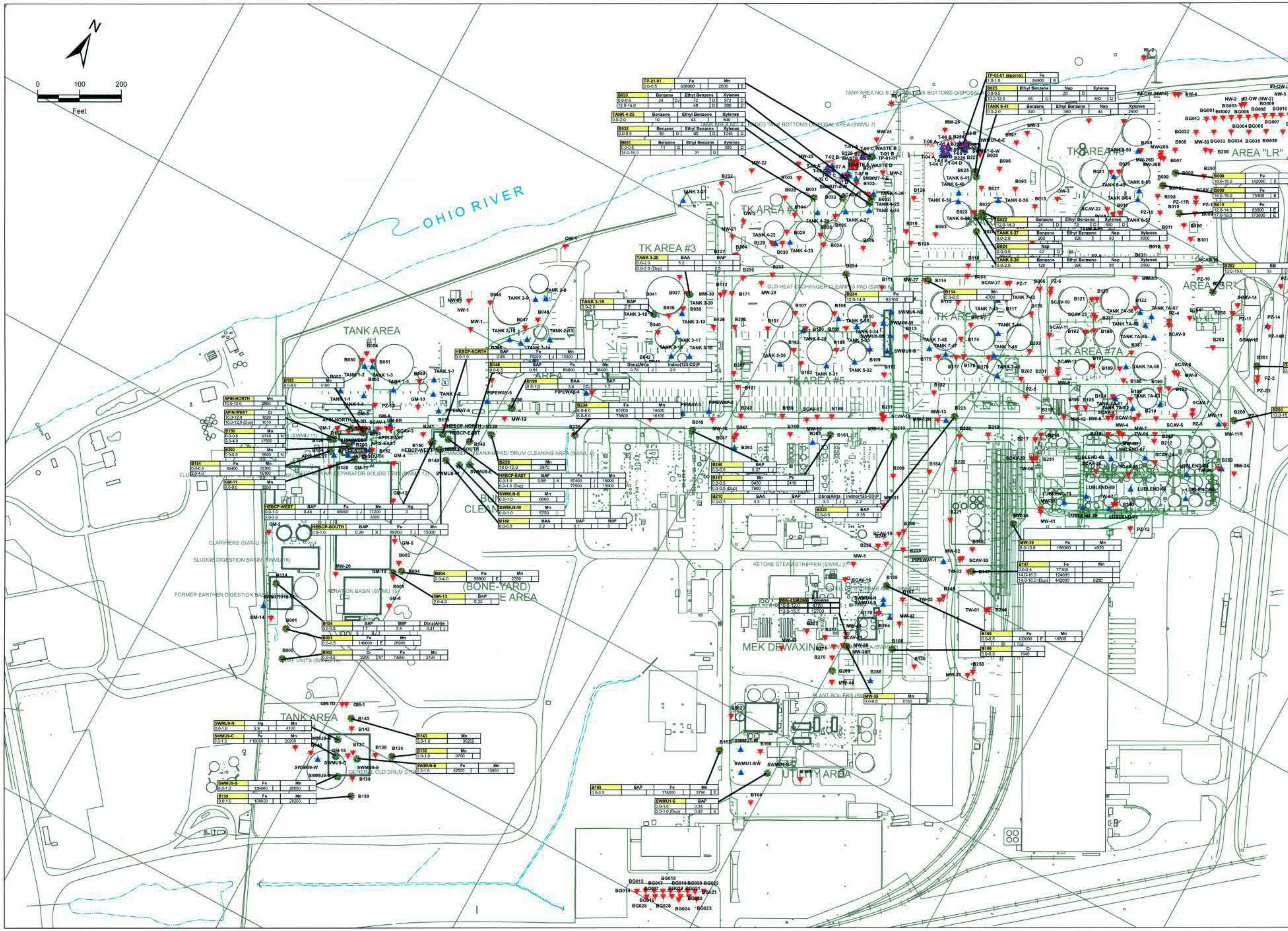
Table B-4
Natural Attenuation Data of Groundwater Samples
Former Quaker State/Ergon Refinery, Newell, WV

Well	*Sample Date*	*Total Alkalinity (mg/L)*	*Total Iron (mg/L)*	*Ferrous Iron (mg/L)*	*Sulfate (mg/L)*	*Nitrate/Nitrate (mg/L)*
SCAV-16						
	6/2/2016	420	90	60	ND(1.0)	ND(0.10)
	6/7/2017	404	70	60	ND(1.0)	ND(0.10)
	6/6/2018	536	45	40	ND(1.0)	ND(0.10)
SCAV-17						
	6/2/2015	263	90	60	ND(10.0)	ND(0.10)
	6/6/2017	318	27	25	1.72	ND(0.10)
	6/6/2018	126	65	65	1.7	ND(0.10)
SCAV-18						
	6/7/2017	476	25	23	23.6	ND(0.10)
SCAV-20						
	6/3/2015	163	45	30	ND(10.0)	ND(0.10)
	6/3/2016	243	45	30	ND(1.0)	ND(0.10)
	6/8/2017	271	NS	30	ND(1.0)	ND(0.10)
	6/6/2018	238	60	45	ND(1.0)	ND(0.10)

Notes:
(mg/L) - milligrams per Liter
ND (100) - Not Detected (Reporting Limit)
NS - Not Sampled
J - Estimated value
f - field duplicate imprecision

Appendix C

RFI Dissolved Phase COC Detections in Groundwater Figures



LEGEND:

- INDUSTRIAL RBC EXCEEDED
- HMI RFI DATA (1998)
- SHAW RFI ADDENDUM DATA (2004-2005)
- TEST PITS
- SWMU

VALIDATION QUALIFIERS:

D - Dilution
E - Exceeds calibration range
J - Detected value, reported value is estimated
N* - Tentative identification
X - Detected above the instrument detection limit, but below the practical quantitation limit

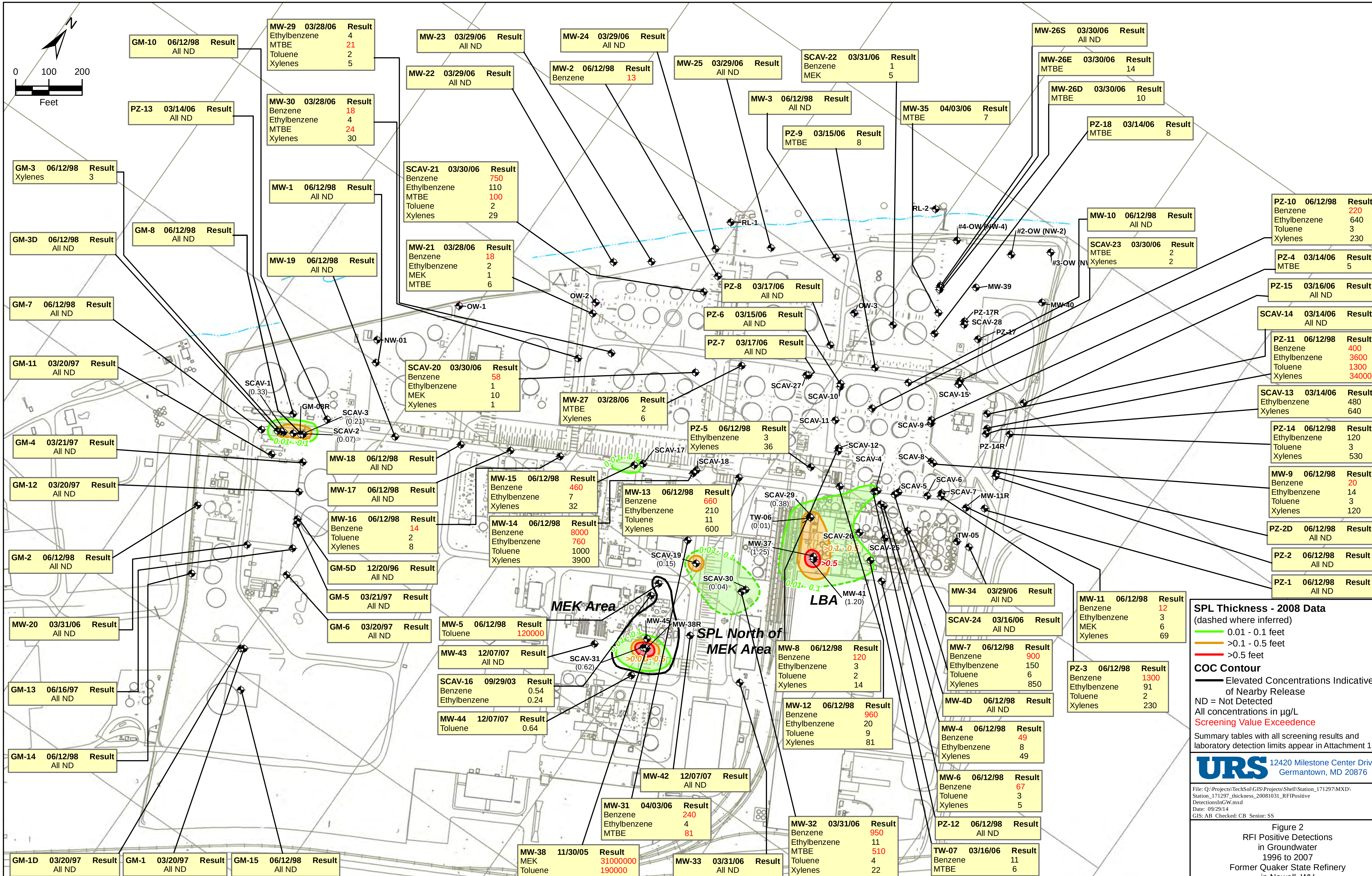
NOTES:

1. Soil sample results are identified by depth collected below ground surface (in feet) and provided in milligrams per kilogram (mg/kg). Duplicate samples noted as (Dup).
2. Sample results exceeding the USEPA Soil Industrial RBC are shown.

URS 200 Orchard Ridge Drive
Gaithersburg, MD 20878

File: G:\Projects\Shell\Station_171297\MXD
Station_171297_full_graphic.mxd
Date: 03/11/09
GIS: KJM/JB, Checked: CB, Senior: SS

Figure 6-3
Industrial RBC Exceedances in Soil
Former Quaker State Facility
Ergon West Virginia, INC.
Newell Refinery, Newell, West Virginia



SPL Thickness - 2008 Data
(dashed where inferred)

- 0.01 - 0.1 feet
- >0.1 - 0.5 feet
- >0.5 feet

COC Contour

- Elevated Concentrations Indicative of Nearby Release

ND = Not Detected
All concentrations in µg/L
Screening Value Exceedence

Summary tables with all screening results and laboratory detection limits appear in Attachment 1

URS 12420 Milestone Center Drive Germantown, MD 20876

File: Q:\Projects\TechSol\GIS\Projects\Shell\Station_171297\MXD\Station_171297_thickness_20081031_RFIPositiveDetectionsInGW.mxd
Date: 09/29/14
GIS: AB Checked: CB Senior: SS

Figure 2
RFI Positive Detections in Groundwater
1996 to 2007
Former Quaker State Refinery in Newell, WV

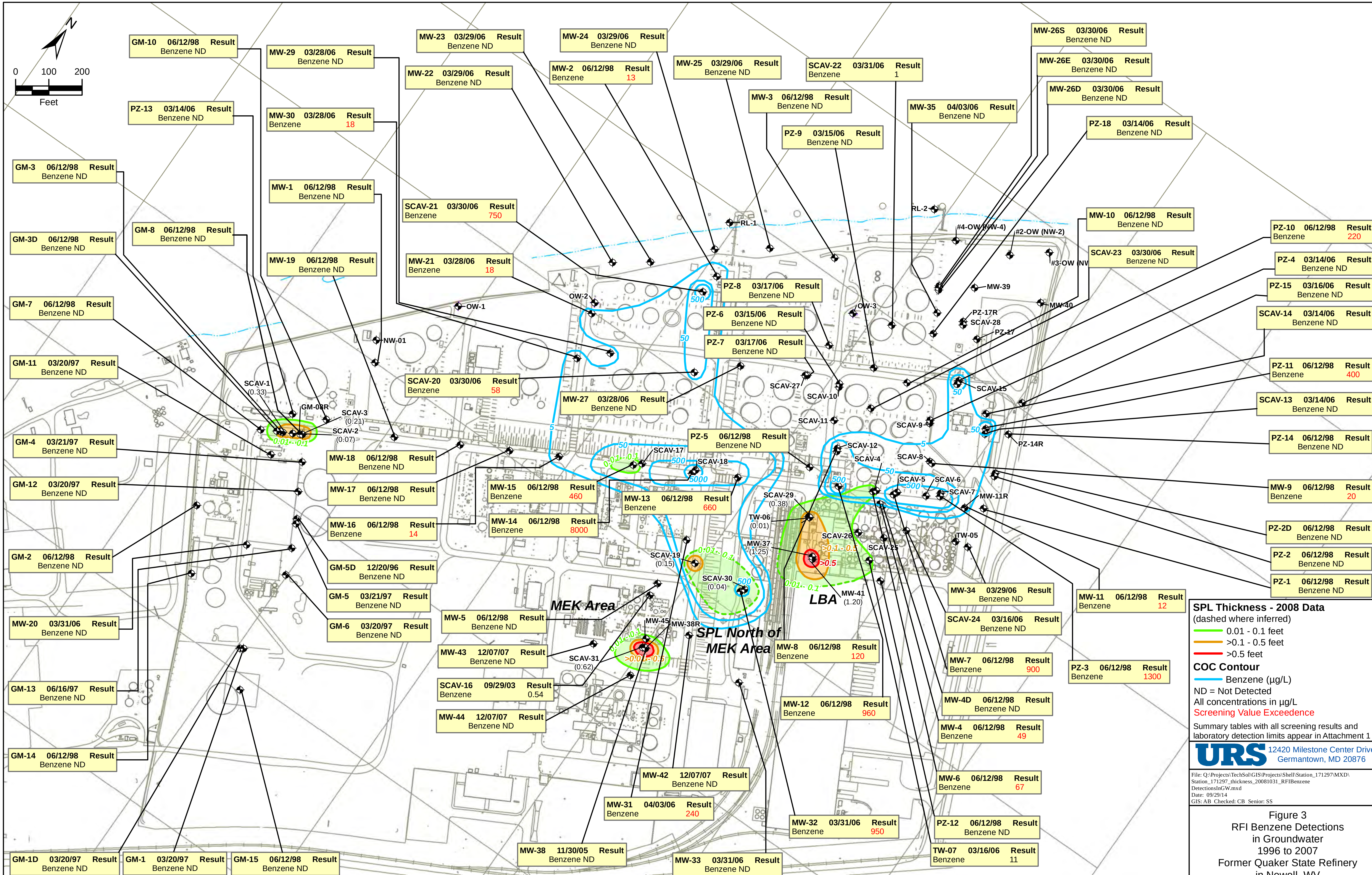


Figure 3
RFI Benzene Detections
in Groundwater
1996 to 2007
Former Quaker State Refinery
in Newell, WV

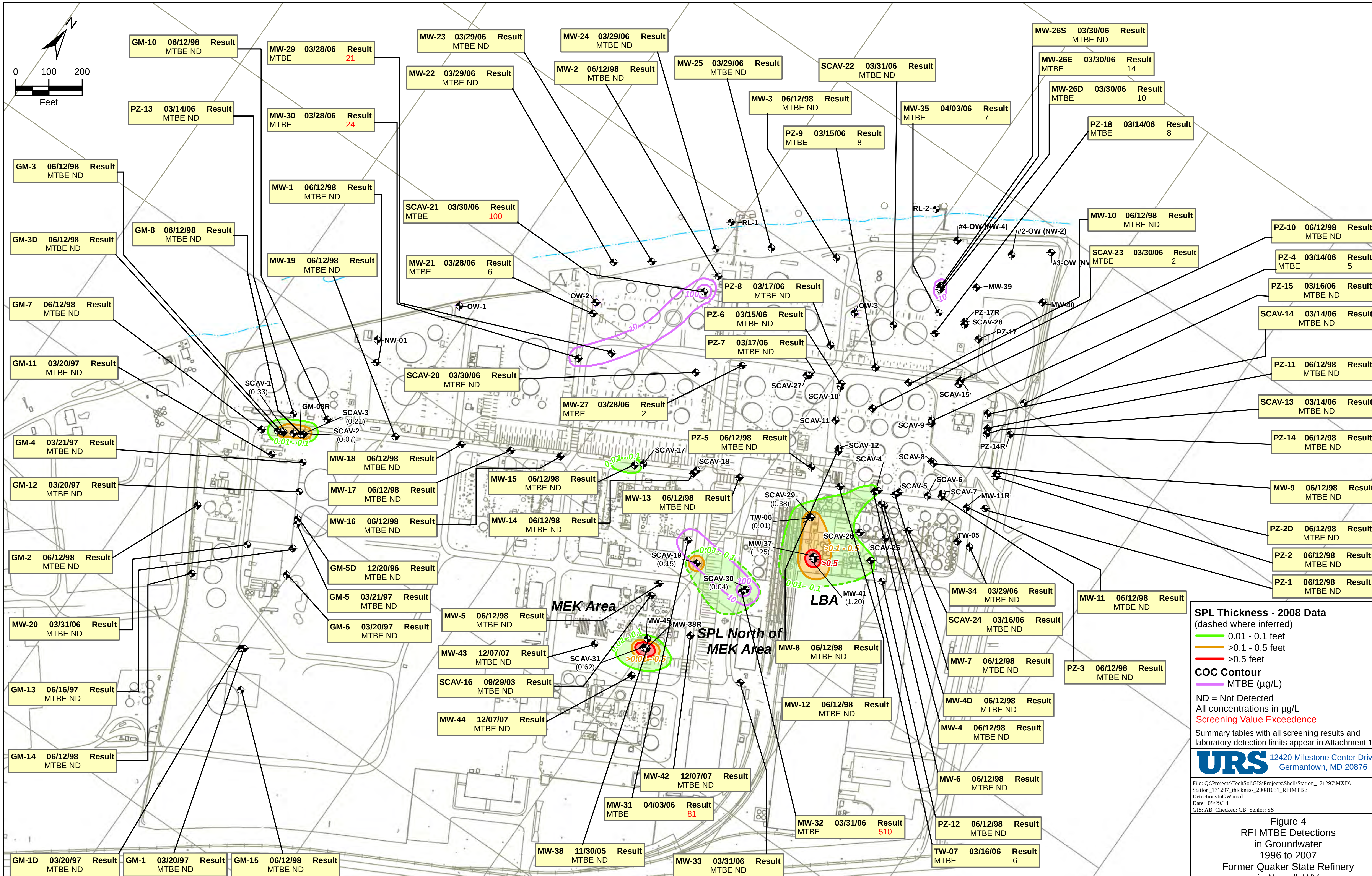
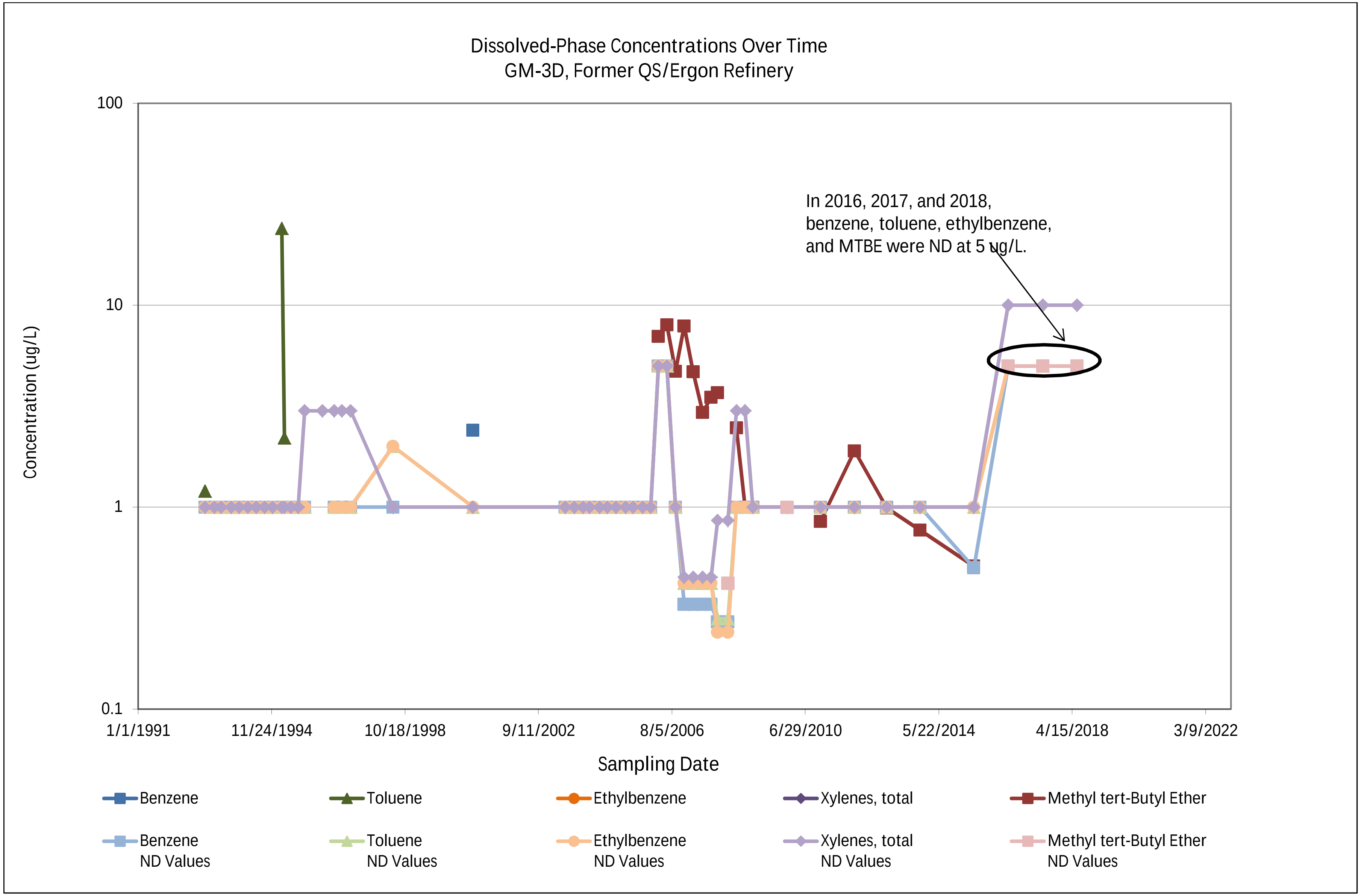
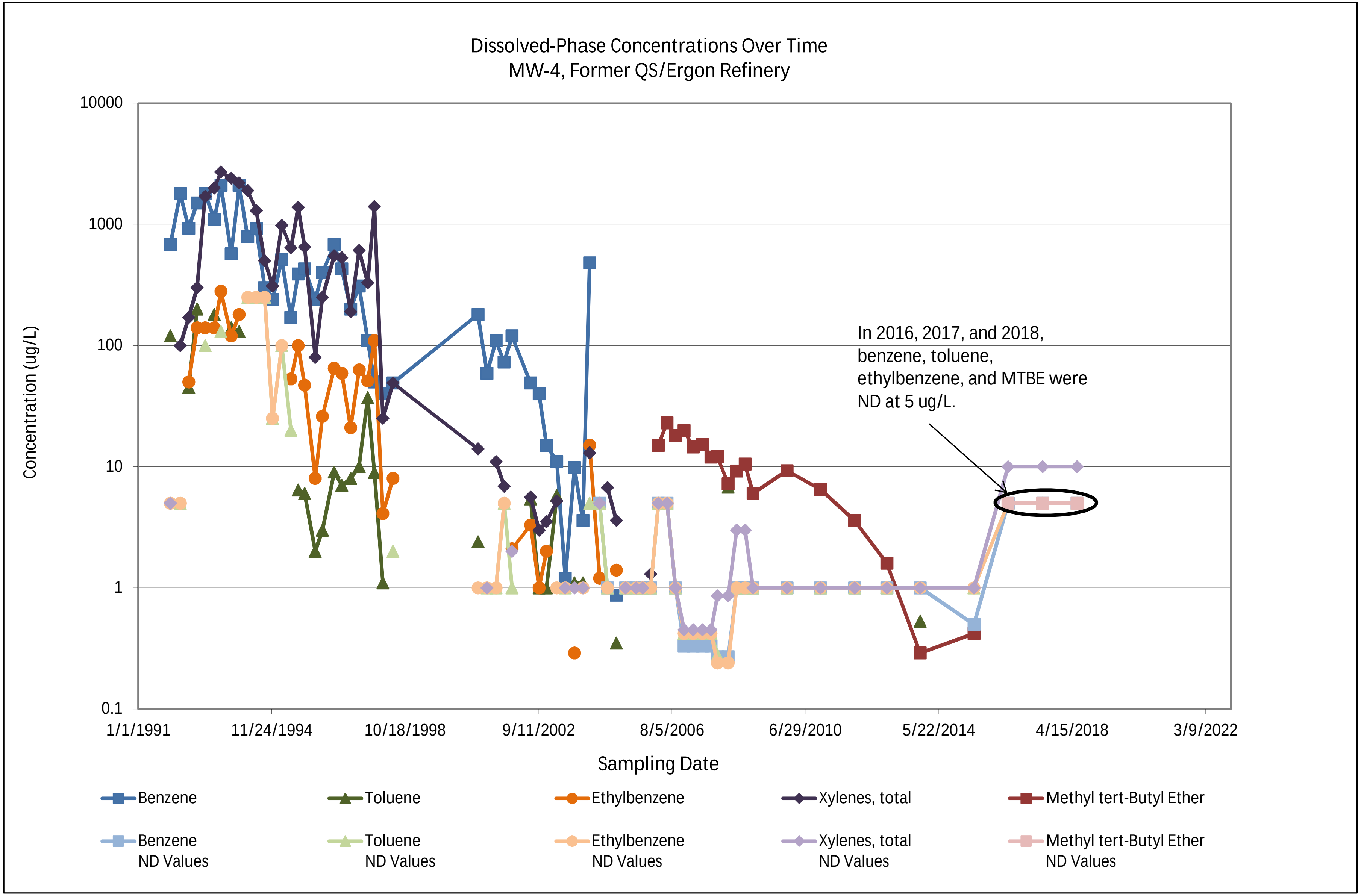


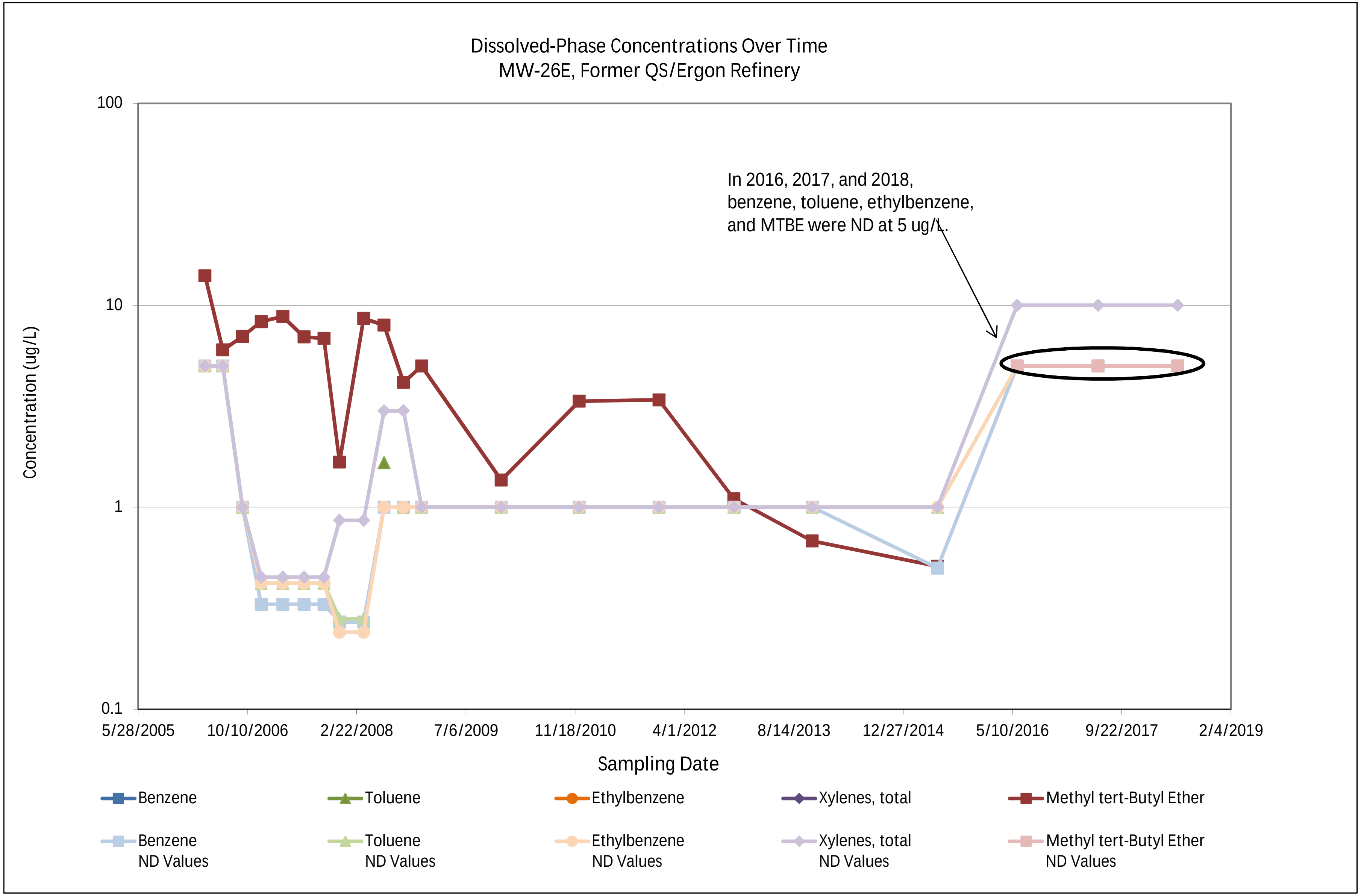
Figure 4
RFI MTBE Detections
in Groundwater
1996 to 2007
Former Quaker State Refinery
in Newell, WV

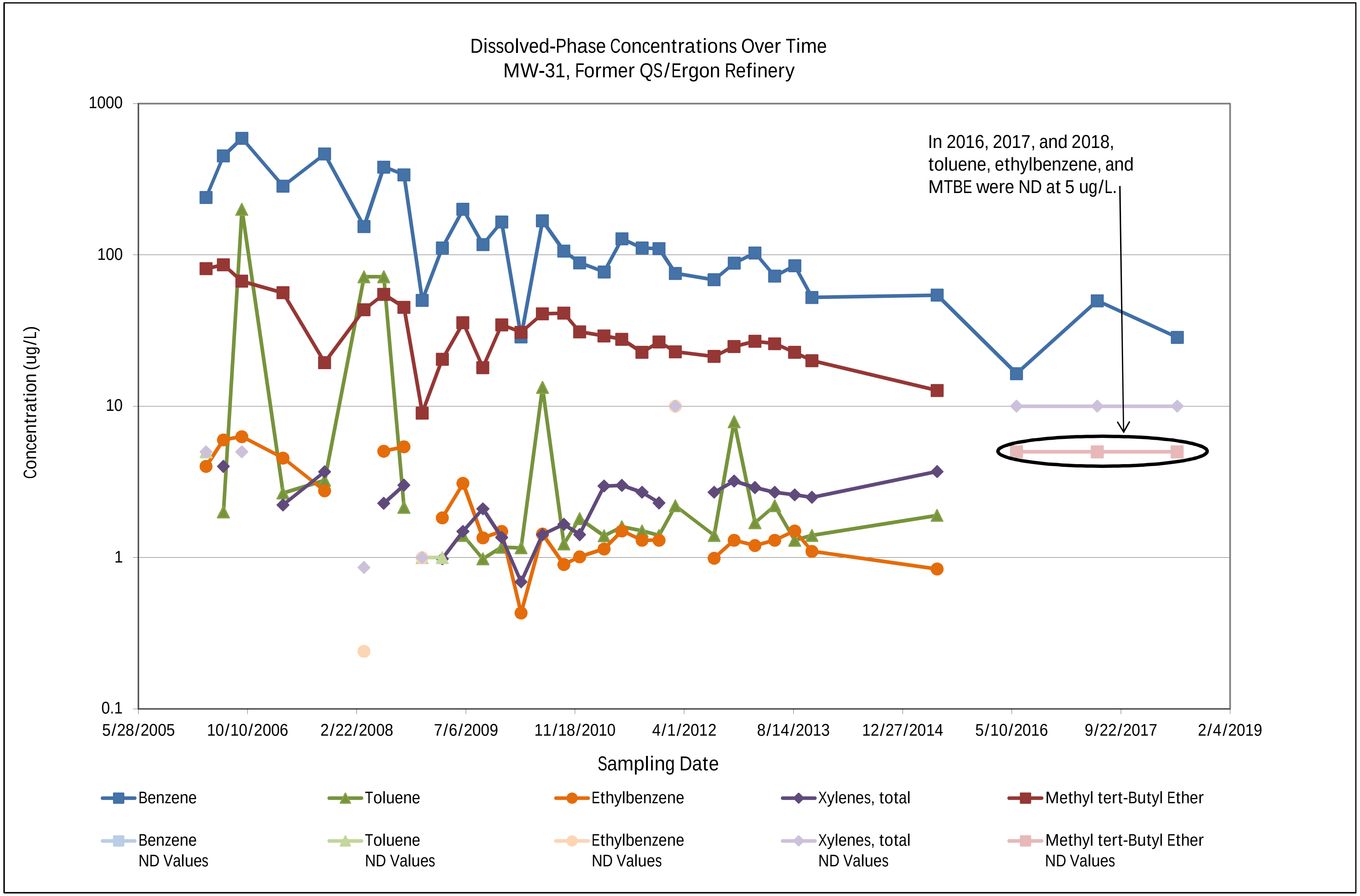
Appendix D

Dissolved Phase Concentration and Mann-Kendall Trend Graphs

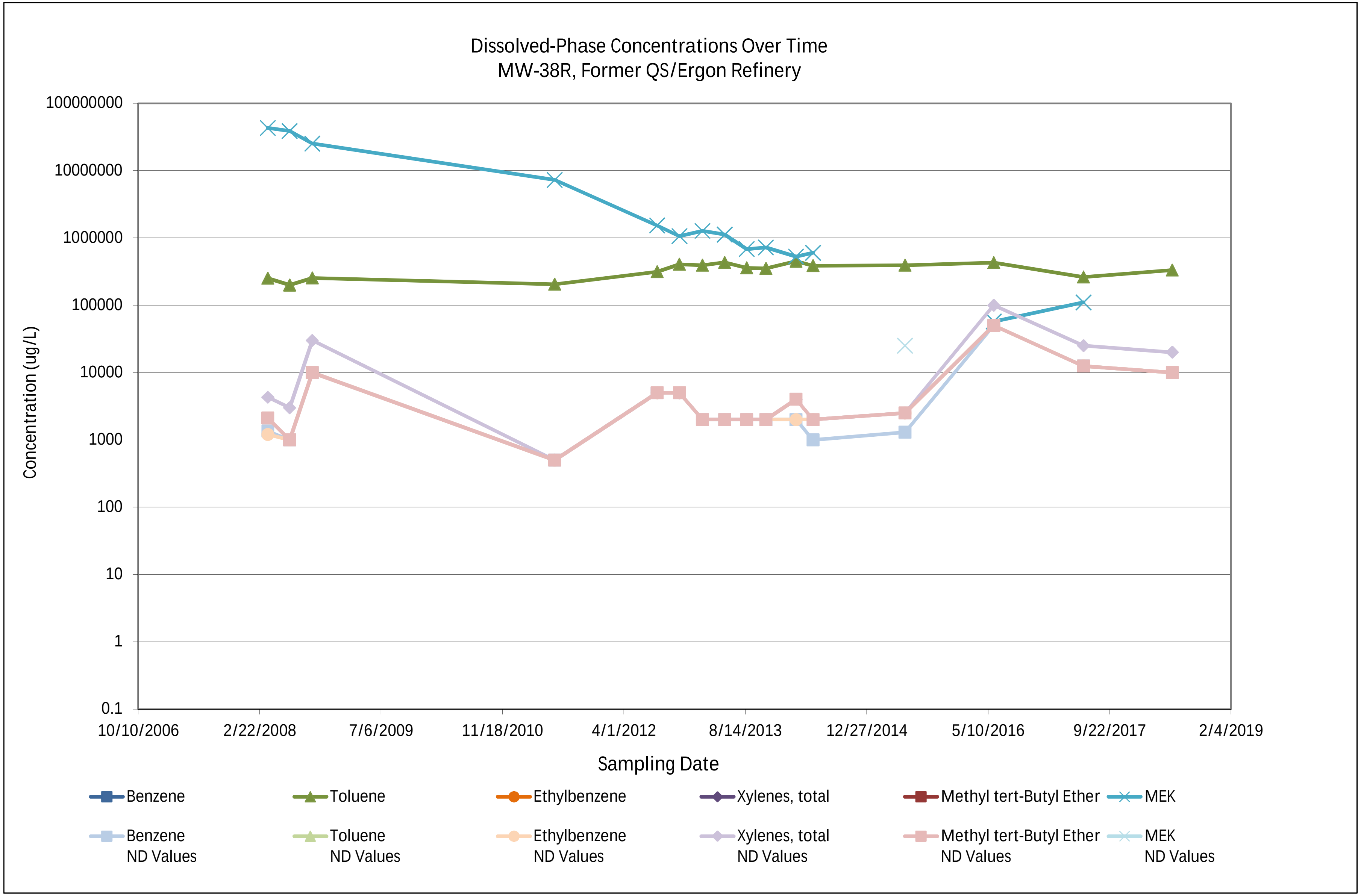

Dissolved-Phase Concentrations Over Time
GM-3D, Former QS/Ergon Refinery
100
10
1
0.1
Concentration (ug/L)
In 2016, 2017, and 2018, benzene, toluene, ethylbenzene, and MTBE were ND at 5 ug/L.
1/1/1991
11/24/1994
10/18/1998
9/11/2002
8/5/2006
6/29/2010
5/22/2014
4/15/2018
3/9/2022
Sampling Date
Benzene
Toluene
Ethylbenzene
Xylenes, total
Methyl tert-Butyl Ether
Benzene ND Values
Toluene ND Values
Ethylbenzene ND Values
Xylenes, total ND Values
Methyl tert-Butyl Ether ND Values


Dissolved-Phase Concentrations Over Time
MW-4, Former QS/Ergon Refinery
Concentration (ug/L)
10000
1000
100
10
1
0.1
1/1/1991
11/24/1994
10/18/1998
9/11/2002
8/5/2006
6/29/2010
5/22/2014
4/15/2018
3/9/2022
Sampling Date
In 2016, 2017, and 2018, benzene, toluene, ethylbenzene, and MTBE were ND at 5 ug/L.
Benzene
Toluene
Ethylbenzene
Xylenes, total
Methyl tert-Butyl Ether
Benzene ND Values
Toluene ND Values
Ethylbenzene ND Values
Xylenes, total ND Values
Methyl tert-Butyl Ether ND Values

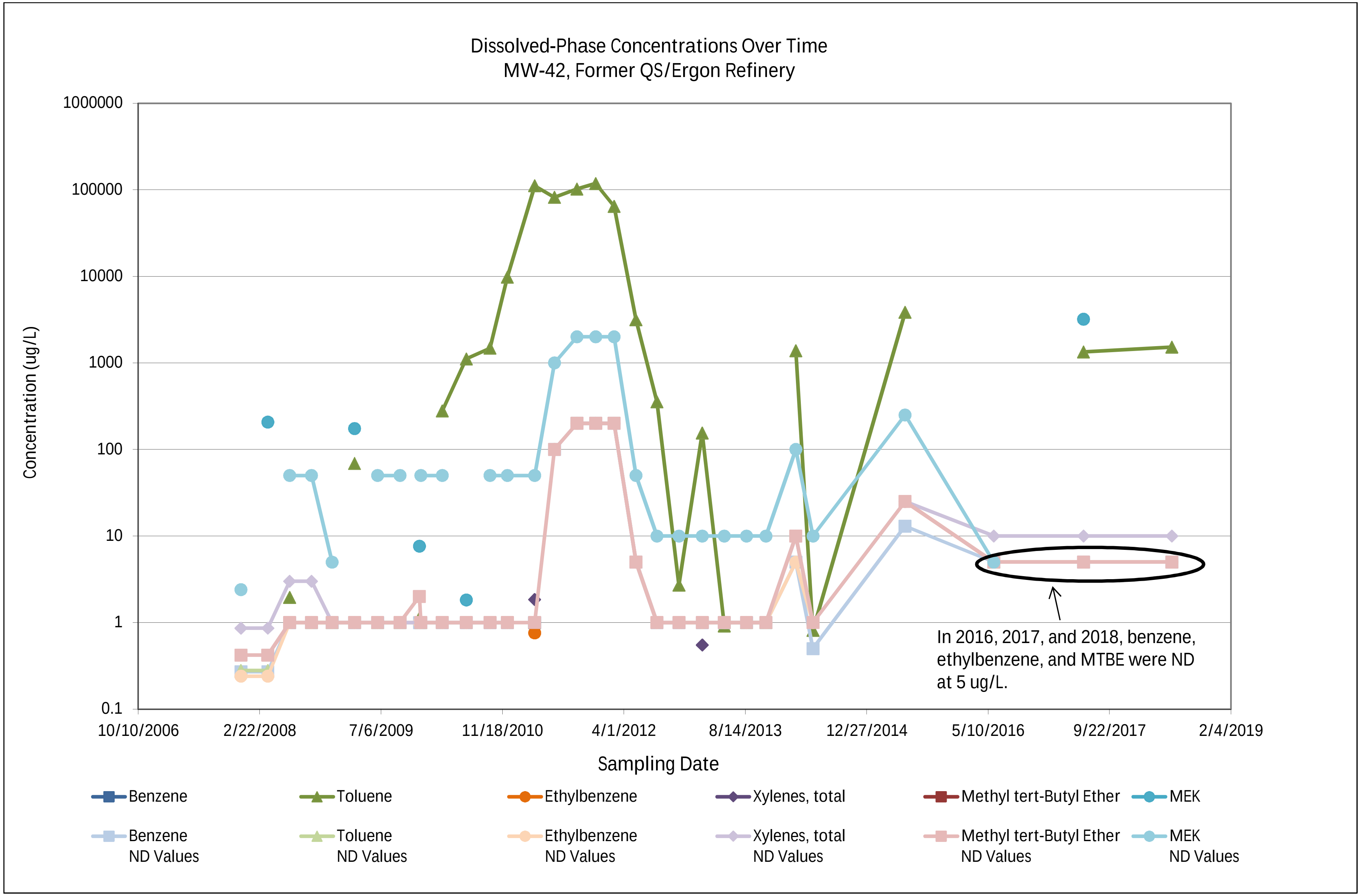

Dissolved-Phase Concentrations Over Time
MW-26E, Former QS/Ergon Refinery
In 2016, 2017, and 2018, benzene, toluene, ethylbenzene, and MTBE were ND at 5 ug/L.
Concentration (ug/L)
100
10
1
0.1
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
5/10/2016
9/22/2017
2/4/2019
Sampling Date
Benzene
Toluene
Ethylbenzene
Xylenes, total
Methyl tert-Butyl Ether
Benzene ND Values
Toluene ND Values
Ethylbenzene ND Values
Xylenes, total ND Values
Methyl tert-Butyl Ether ND Values



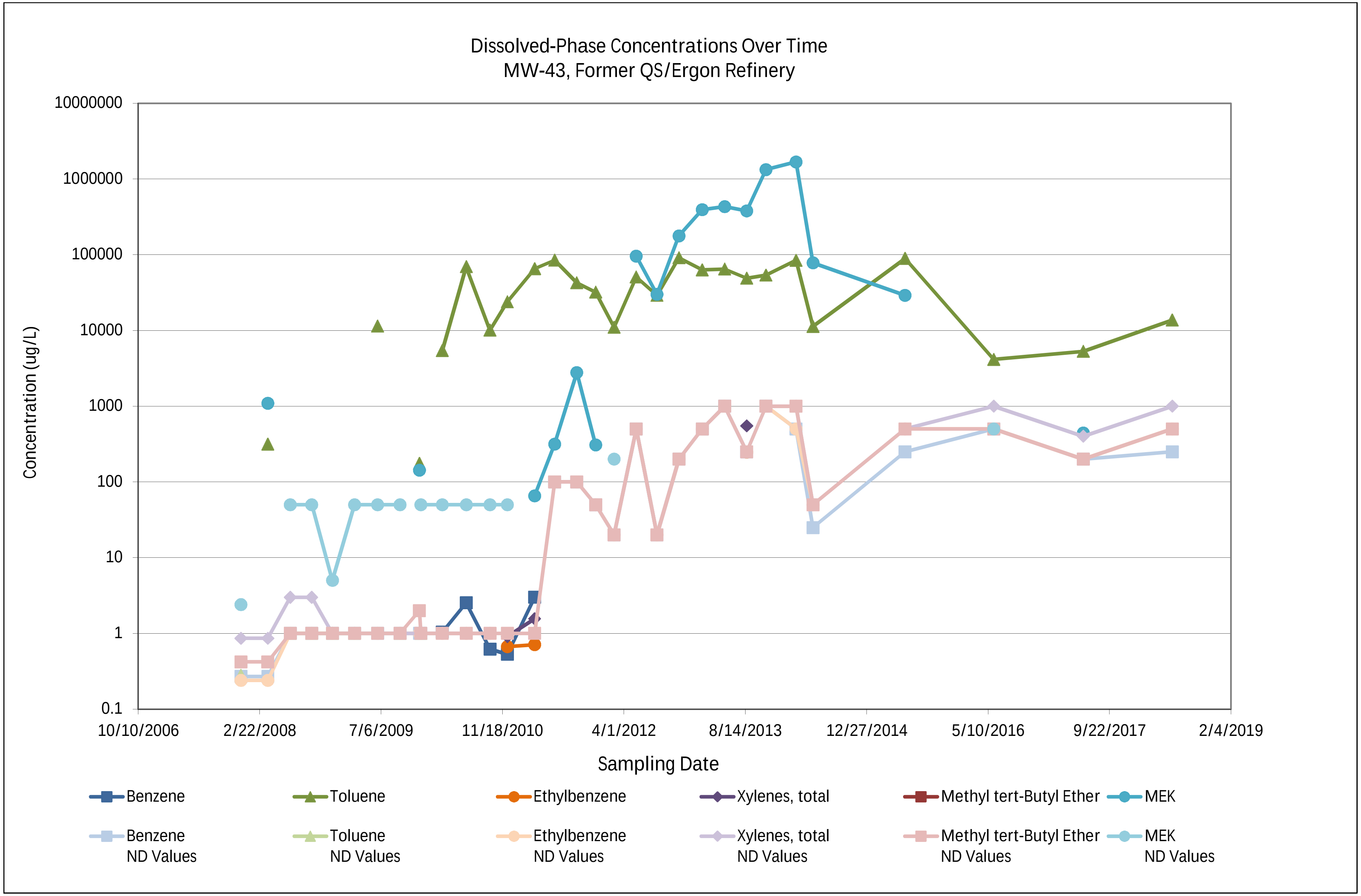
Dissolved-Phase Concentrations Over Time
MW-31, Former QS/Ergon Refinery
In 2016, 2017, and 2018, toluene, ethylbenzene, and MTBE were ND at 5 ug/L.
Concentration (ug/L)
1000
100
10
1
0.1
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
5/10/2016
9/22/2017
2/4/2019
Sampling Date
Benzene
Toluene
Ethylbenzene
Xylenes, total
Methyl tert-Butyl Ether
Benzene ND Values
Toluene ND Values
Ethylbenzene ND Values
Xylenes, total ND Values
Methyl tert-Butyl Ether ND Values

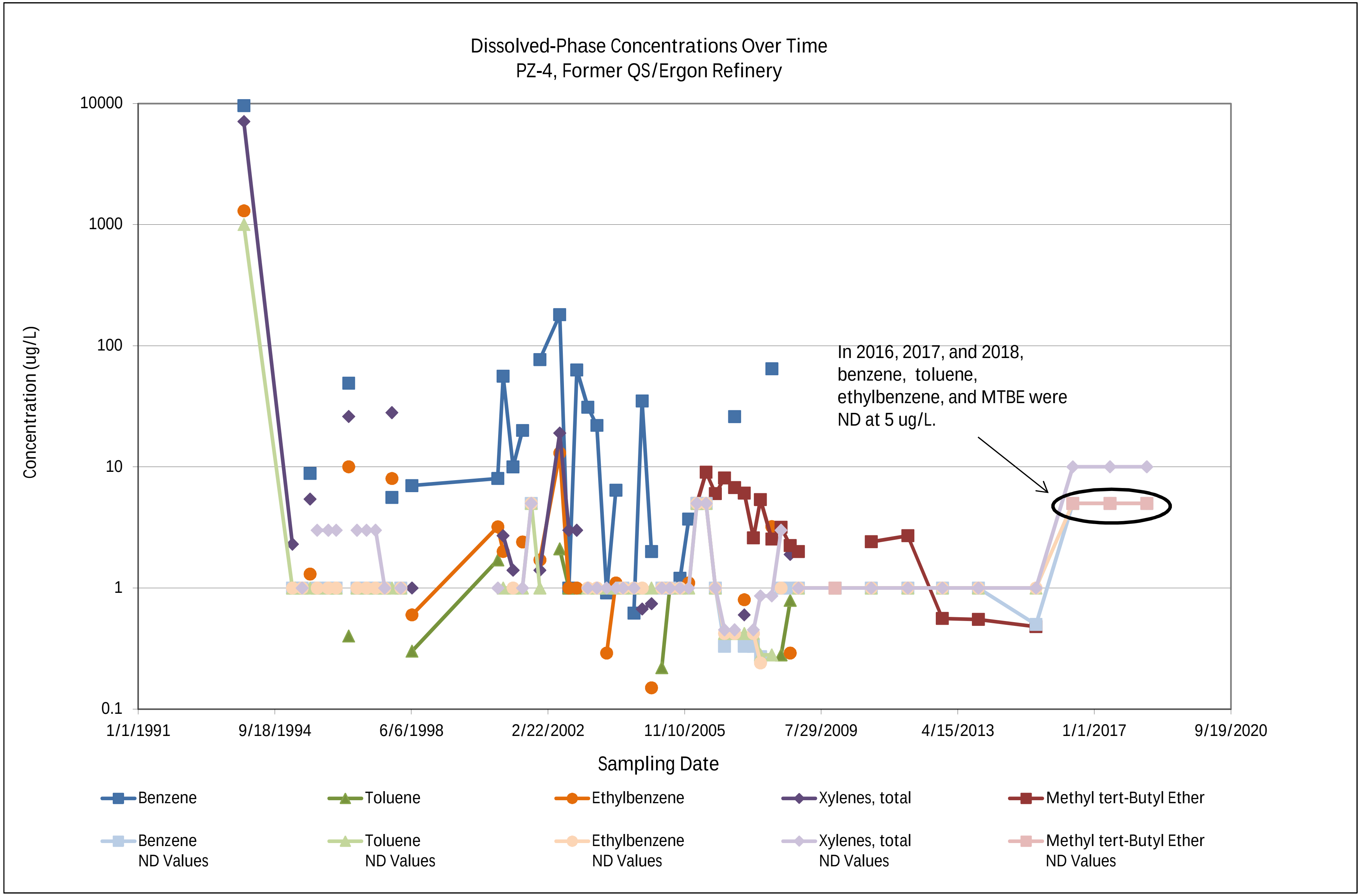


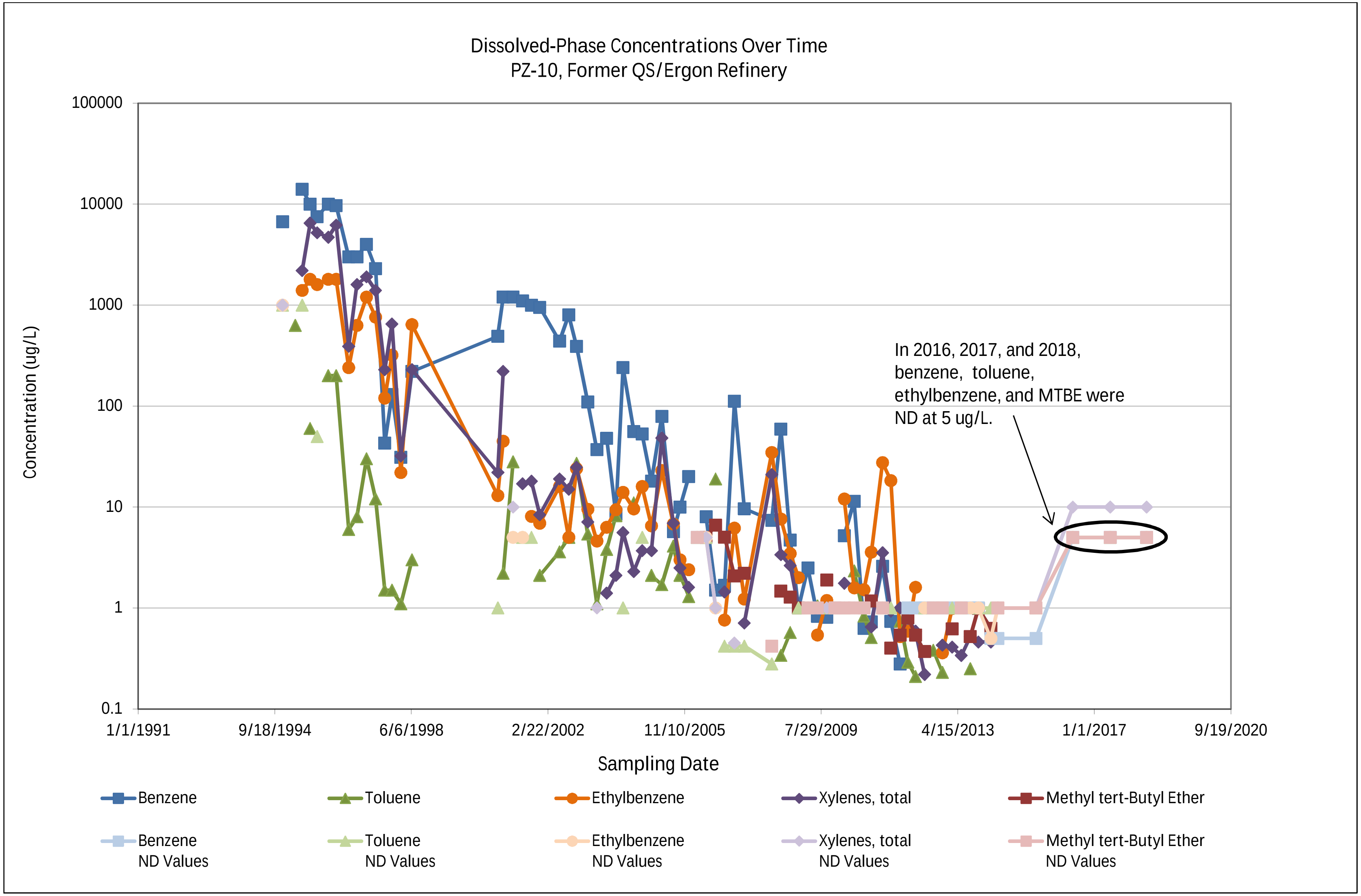
Dissolved-Phase Concentrations Over Time
MW-38R, Former QS/Ergon Refinery
100000000
10000000
1000000
100000
10000
1000
100
10
1
0.1
Concentration (ug/L)
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
5/10/2016
9/22/2017
2/4/2019
Sampling Date
Benzene
Toluene
Ethylbenzene
Xylenes, total
Methyl tert-Butyl Ether
MEK
Benzene ND Values
Toluene ND Values
Ethylbenzene ND Values
Xylenes, total ND Values
Methyl tert-Butyl Ether ND Values
MEK ND Values



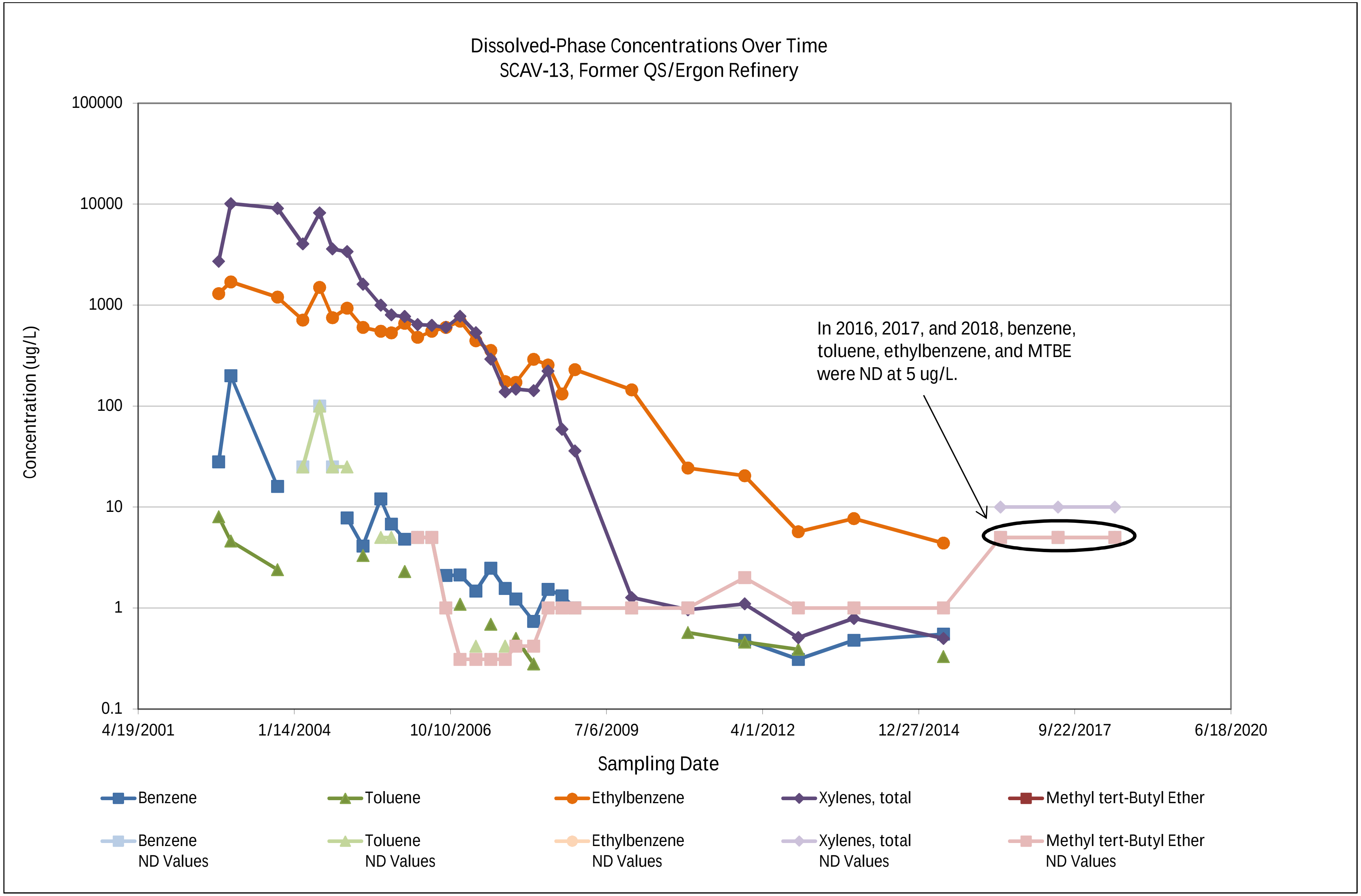
Dissolved-Phase Concentrations Over Time
MW-42, Former QS/Ergon Refinery
1000000
100000
10000
1000
100
10
1
0.1
Concentration (ug/L)
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
5/10/2016
9/22/2017
2/4/2019
Sampling Date
In 2016, 2017, and 2018, benzene, ethylbenzene, and MTBE were ND at 5 ug/L.
Benzene
Toluene
Ethylbenzene
Xylenes, total
Methyl tert-Butyl Ether
MEK
Benzene ND Values
Toluene ND Values
Ethylbenzene ND Values
Xylenes, total ND Values
Methyl tert-Butyl Ether ND Values
MEK ND Values

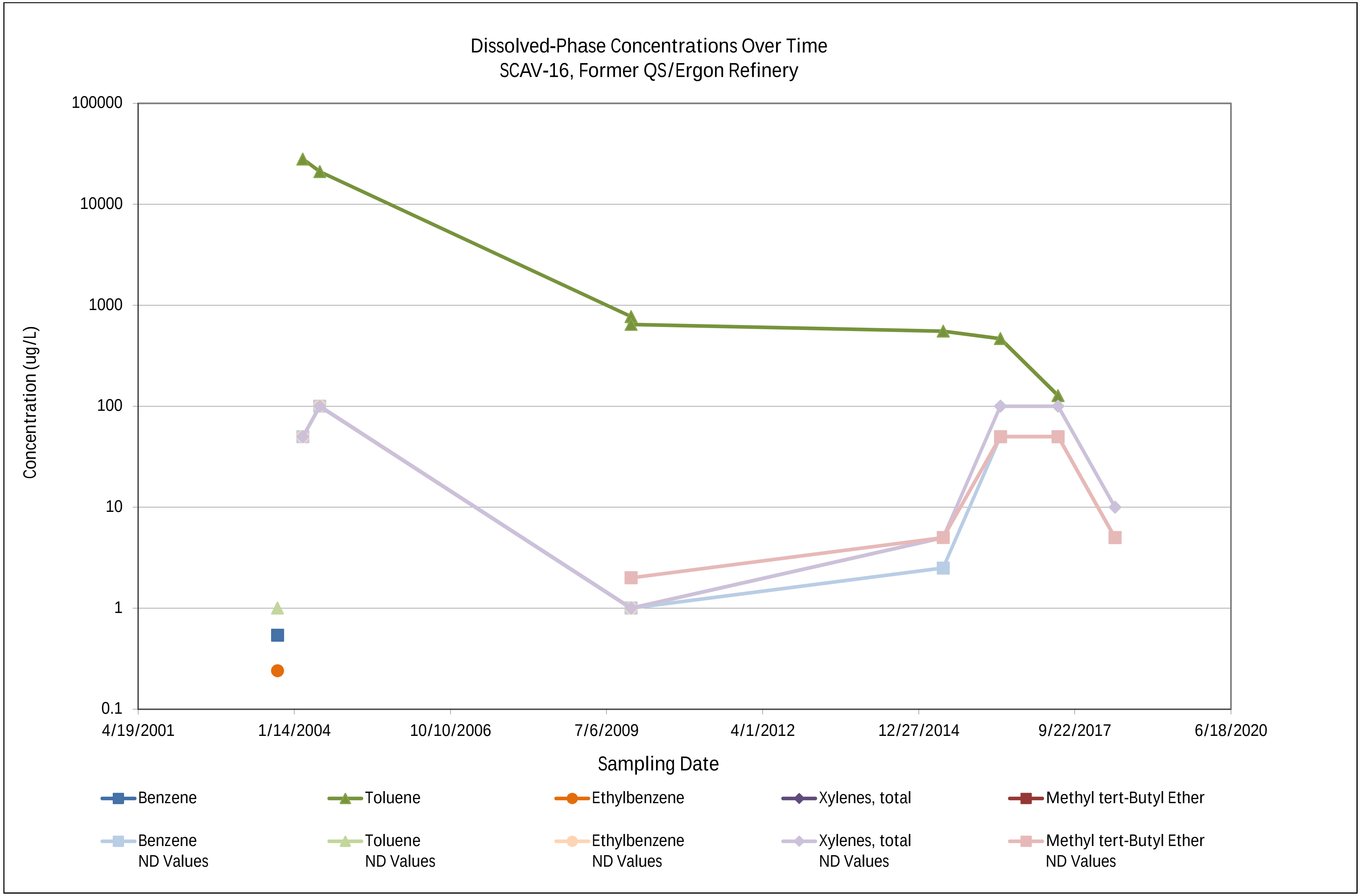

Dissolved-Phase Concentrations Over Time
MW-43, Former QS/Ergon Refinery
10000000
1000000
100000
10000
1000
100
10
1
0.1
Concentration (ug/L)
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
5/10/2016
9/22/2017
2/4/2019
Sampling Date
Benzene
Toluene
Ethylbenzene
Xylenes, total
Methyl tert-Butyl Ether
MEK
Benzene ND Values
Toluene ND Values
Ethylbenzene ND Values
Xylenes, total ND Values
Methyl tert-Butyl Ether ND Values
MEK ND Values


Dissolved-Phase Concentrations Over Time
PZ-4, Former QS/Ergon Refinery
Concentration (ug/L)
10000
1000
100
10
1
0.1
1/1/1991
9/18/1994
6/6/1998
2/22/2002
11/10/2005
7/29/2009
4/15/2013
1/1/2017
9/19/2020
Sampling Date
In 2016, 2017, and 2018, benzene, toluene, ethylbenzene, and MTBE were ND at 5 ug/L.
Benzene
Toluene
Ethylbenzene
Xylenes, total
Methyl tert-Butyl Ether
Benzene ND Values
Toluene ND Values
Ethylbenzene ND Values
Xylenes, total ND Values
Methyl tert-Butyl Ether ND Values

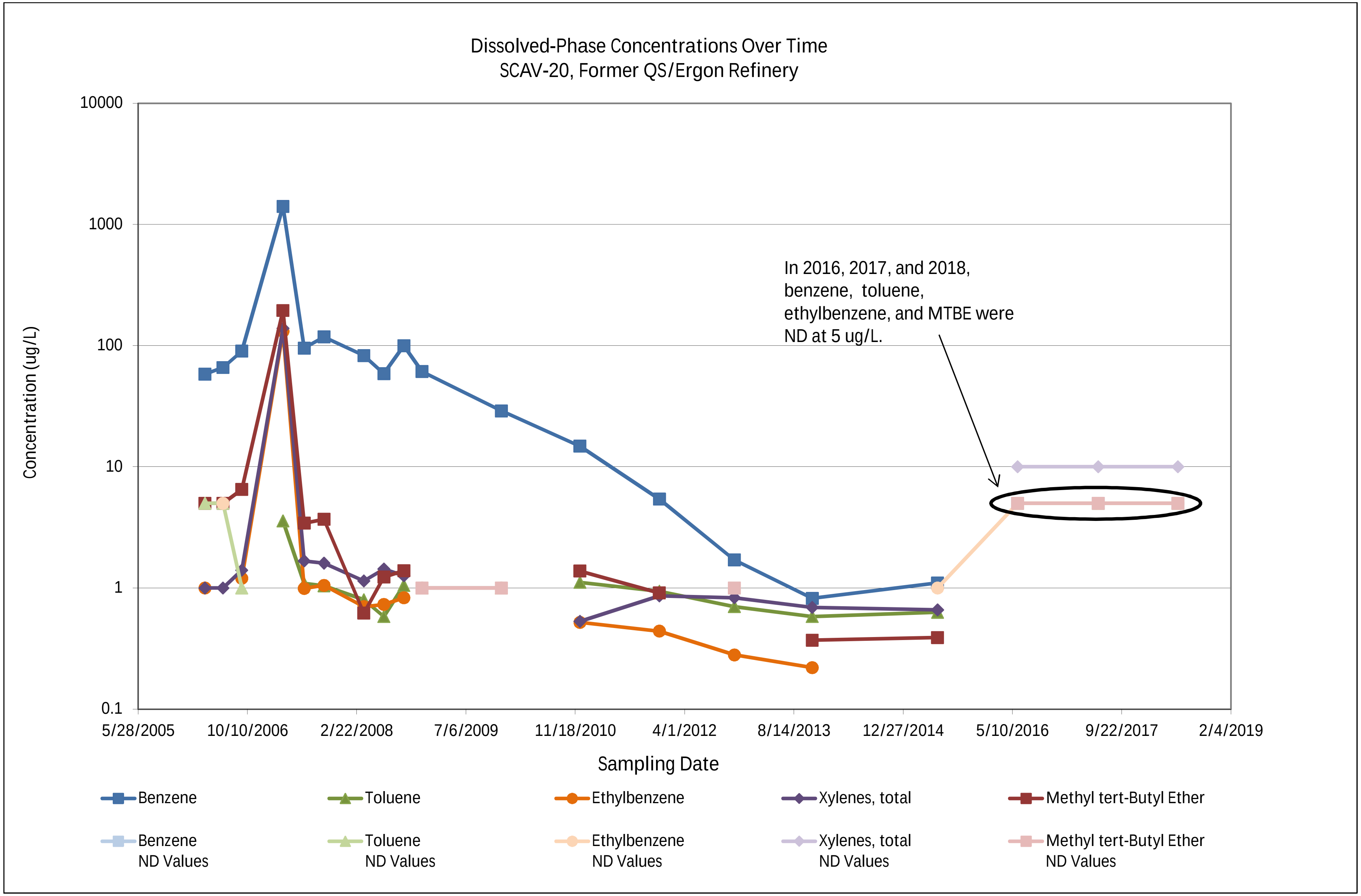


Dissolved-Phase Concentrations Over Time
PZ-10, Former QS/Ergon Refinery
Concentration (ug/L)
100000
10000
1000
100
10
1
0.1
1/1/1991
9/18/1994
6/6/1998
2/22/2002
11/10/2005
7/29/2009
4/15/2013
1/1/2017
9/19/2020
Sampling Date
In 2016, 2017, and 2018, benzene, toluene, ethylbenzene, and MTBE were ND at 5 ug/L.
Benzene
Toluene
Ethylbenzene
Xylenes, total
Methyl tert-Butyl Ether
Benzene ND Values
Toluene ND Values
Ethylbenzene ND Values
Xylenes, total ND Values
Methyl tert-Butyl Ether ND Values


Dissolved-Phase Concentrations Over Time
SCAV-13, Former QS/Ergon Refinery
100000
10000
1000
100
10
1
0.1
Concentration (ug/L)
4/19/2001
1/14/2004
10/10/2006
7/6/2009
4/1/2012
12/27/2014
9/22/2017
6/18/2020
Sampling Date
In 2016, 2017, and 2018, benzene, toluene, ethylbenzene, and MTBE were ND at 5 ug/L.
Benzene
Toluene
Ethylbenzene
Xylenes, total
Methyl tert-Butyl Ether
Benzene ND Values
Toluene ND Values
Ethylbenzene ND Values
Xylenes, total ND Values
Methyl tert-Butyl Ether ND Values



Dissolved-Phase Concentrations Over Time
SCAV-16, Former QS/Ergon Refinery
Concentration (ug/L)
100000
10000
1000
100
10
1
0.1
4/19/2001
1/14/2004
10/10/2006
7/6/2009
4/1/2012
12/27/2014
9/22/2017
6/18/2020
Sampling Date
Benzene
Toluene
Ethylbenzene
Xylenes, total
Methyl tert-Butyl Ether
Benzene ND Values
Toluene ND Values
Ethylbenzene ND Values
Xylenes, total ND Values
Methyl tert-Butyl Ether ND Values


Dissolved-Phase Concentrations Over Time
SCAV-20, Former QS/Ergon Refinery
10000
1000
100
10
1
0.1
Concentration (ug/L)
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
5/10/2016
9/22/2017
2/4/2019
Sampling Date
In 2016, 2017, and 2018, benzene, toluene, ethylbenzene, and MTBE were ND at 5 ug/L.
Benzene
Toluene
Ethylbenzene
Xylenes, total
Methyl tert-Butyl Ether
Benzene ND Values
Toluene ND Values
Ethylbenzene ND Values
Xylenes, total ND Values
Methyl tert-Butyl Ether ND Values

MW-31

Mann-Kendall Trend Test Analysis

Mann-Kendall Trend Test Analysis

User Selected Options	
Date/Time of Computation	ProUCL 5.18/8/2018 3:36:40 PM
From File	MW-31 ProUCL Input.xls
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

Concentration (ug/L) - MW-31-benzene

General Statistics

Number of Events Reported (m)	32
Number of Missing Events	0
Number or Reported Events Used	32
Number Values Reported (n)	32
Minimum	16.4
Maximum	590
Mean	158
Geometric Mean	111.9
Median	108
Standard Deviation	142.6
Coefficient of Variation	0.902

Mann-Kendall Test

M-K Test Value (S)	-325
Critical Value (0.05)	-1.645
Standard Deviation of S	61.66
Standardized Value of S	-5.255
Approximate p-value	7.4084E-8

Statistically significant evidence of a decreasing
trend at the specified level of significance.

Concentration (ug/L) - MW-31-methyl tert-butyl ether

General Statistics

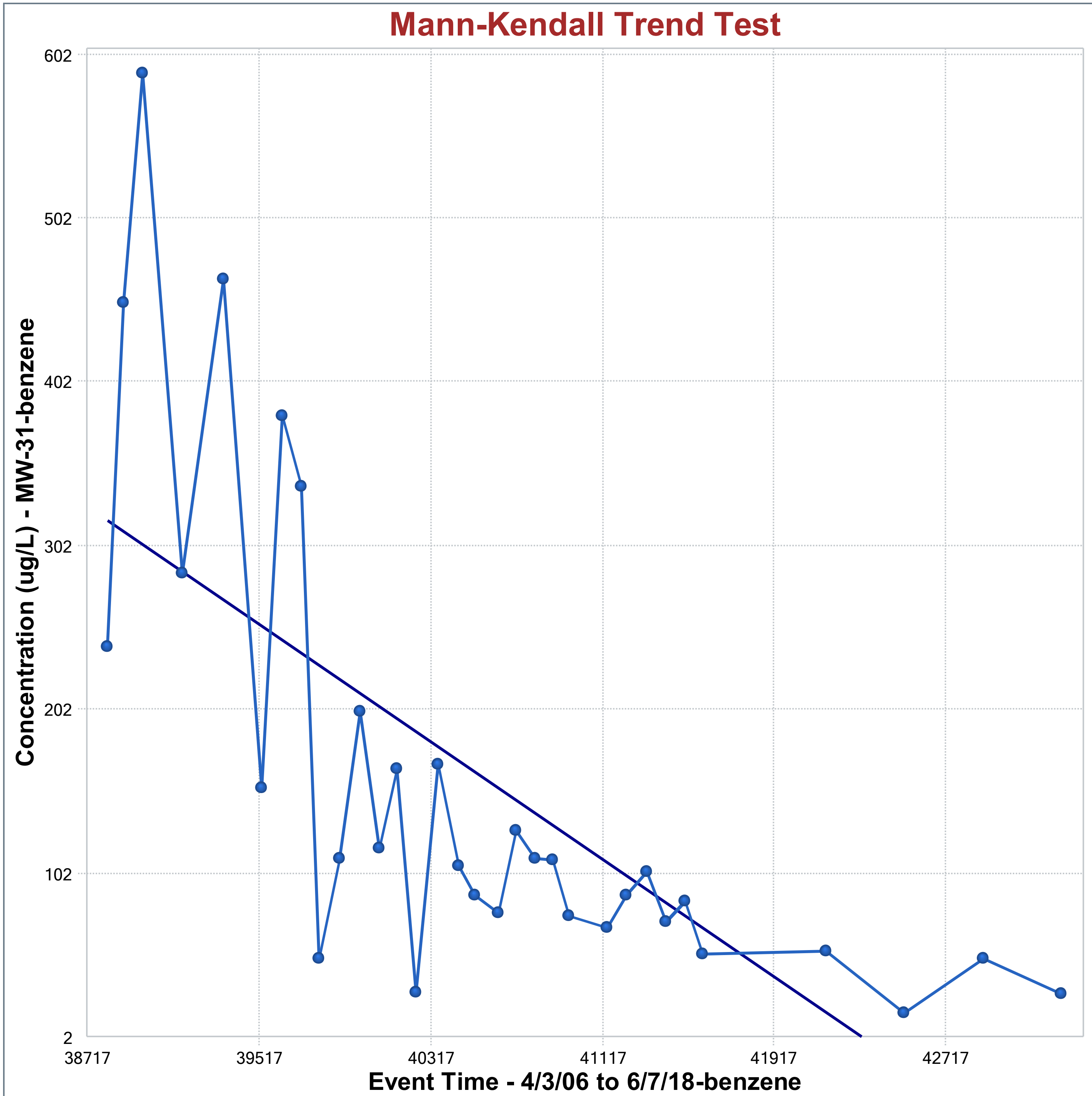
Number of Events Reported (m)	32
Number of Missing Events	0
Number or Reported Events Used	32
Number Values Reported (n)	32
Minimum	5
Maximum	86
Mean	31.64
Geometric Mean	25.52
Median	26.7
Standard Deviation	20

Coefficient of Variation	0.632

Mann-Kendall Test

M-K Test Value (S)	-294
Critical Value (0.05)	-1.645
Standard Deviation of S	61.63
Standardized Value of S	-4.754
Approximate p-value	9.9548E-7

Statistically significant evidence of a decreasing trend at the specified level of significance.



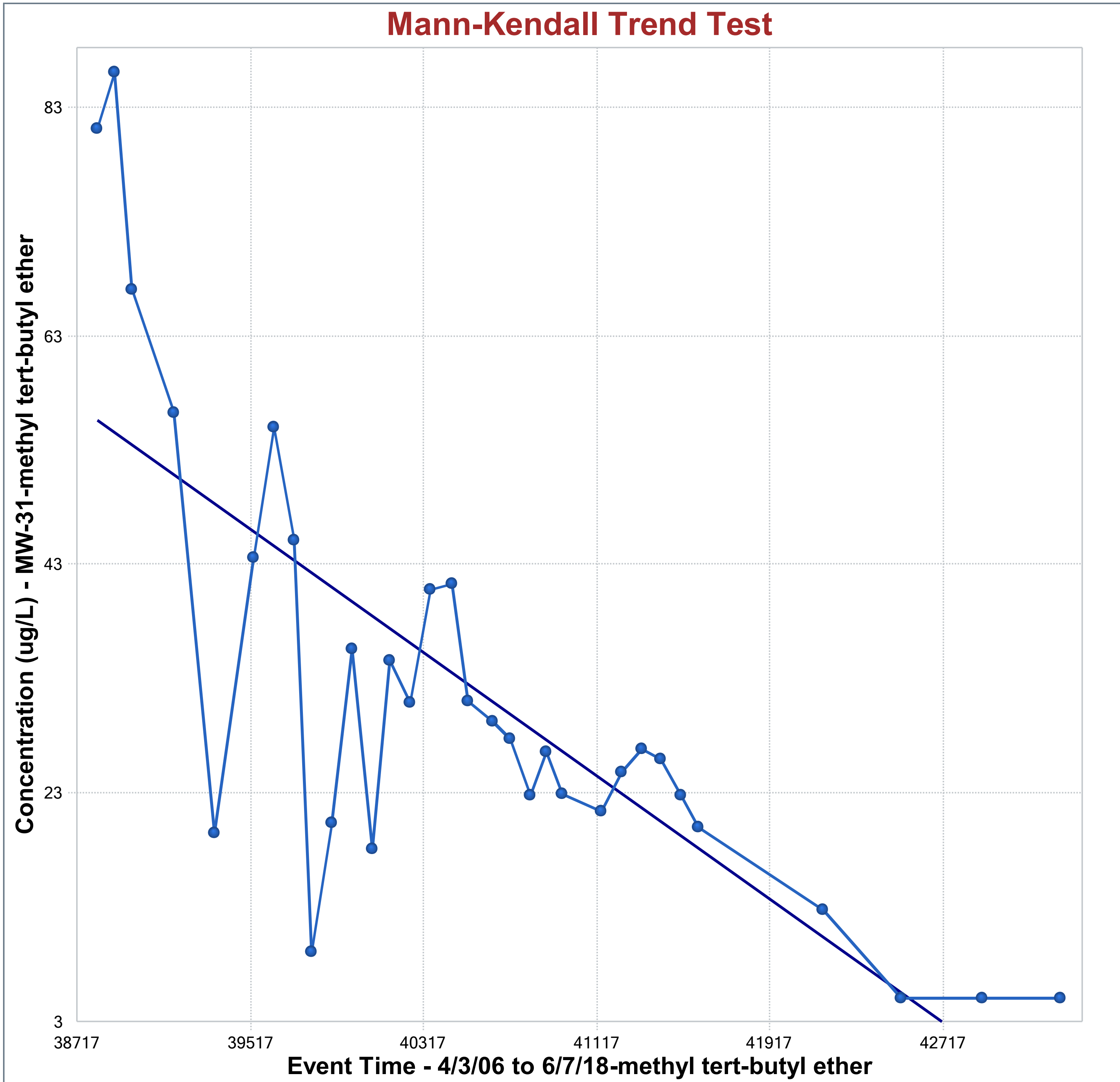
Mann-Kendall Trend Analysis

n	32
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	61.6577
Standardized Value of S	-5.2548
M-K Test Value (S)	-325
Appx. Critical Value (0.05)	-1.6449
Approximate p-value	0.0000

OLS Regression Line (Blue)

OLS Regression Slope	-0.0898
OLS Regression Intercept	3,801.0707

Statistically significant evidence of a decreasing trend at the specified level of significance.



Mann-Kendall Trend Analysis

n	32
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	61.6279
Standardized Value of S	-4.7543
M-K Test Value (S)	-294
Appx. Critical Value (0.05)	-1.6449
Approximate p-value	0.0000

OLS Regression Line (Blue)

OLS Regression Slope	-0.0135
OLS Regression Intercept	578.9189

Statistically significant evidence of a decreasing trend at the specified level of significance.

MW-38R

Mann-Kendall Trend Test Analysis

Mann-Kendall Trend Test Analysis

User Selected Options	
Date/Time of Computation	ProUCL 5.18/8/2018 3:37:50 PM
From File	MW-38R Input.xls
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

Concentration (ug/L) - MW-38R-mek

General Statistics

Number of Events Reported (m)	16
Number of Missing Events	0
Number or Reported Events Used	16
Number Values Reported (n)	16
Minimum	10000
Maximum	42900000
Mean	7610763
Geometric Mean	895646
Median	891000
Standard Deviation	14392217
Coefficient of Variation	1.891

Mann-Kendall Test

M-K Test Value (S)	-106
Tabulated p-value	0
Standard Deviation of S	22.21
Standardized Value of S	-4.727
Approximate p-value	1.1373E-6

Statistically significant evidence of a decreasing trend at the specified level of significance.

Concentration (ug/L) - MW-38R-toluene

General Statistics

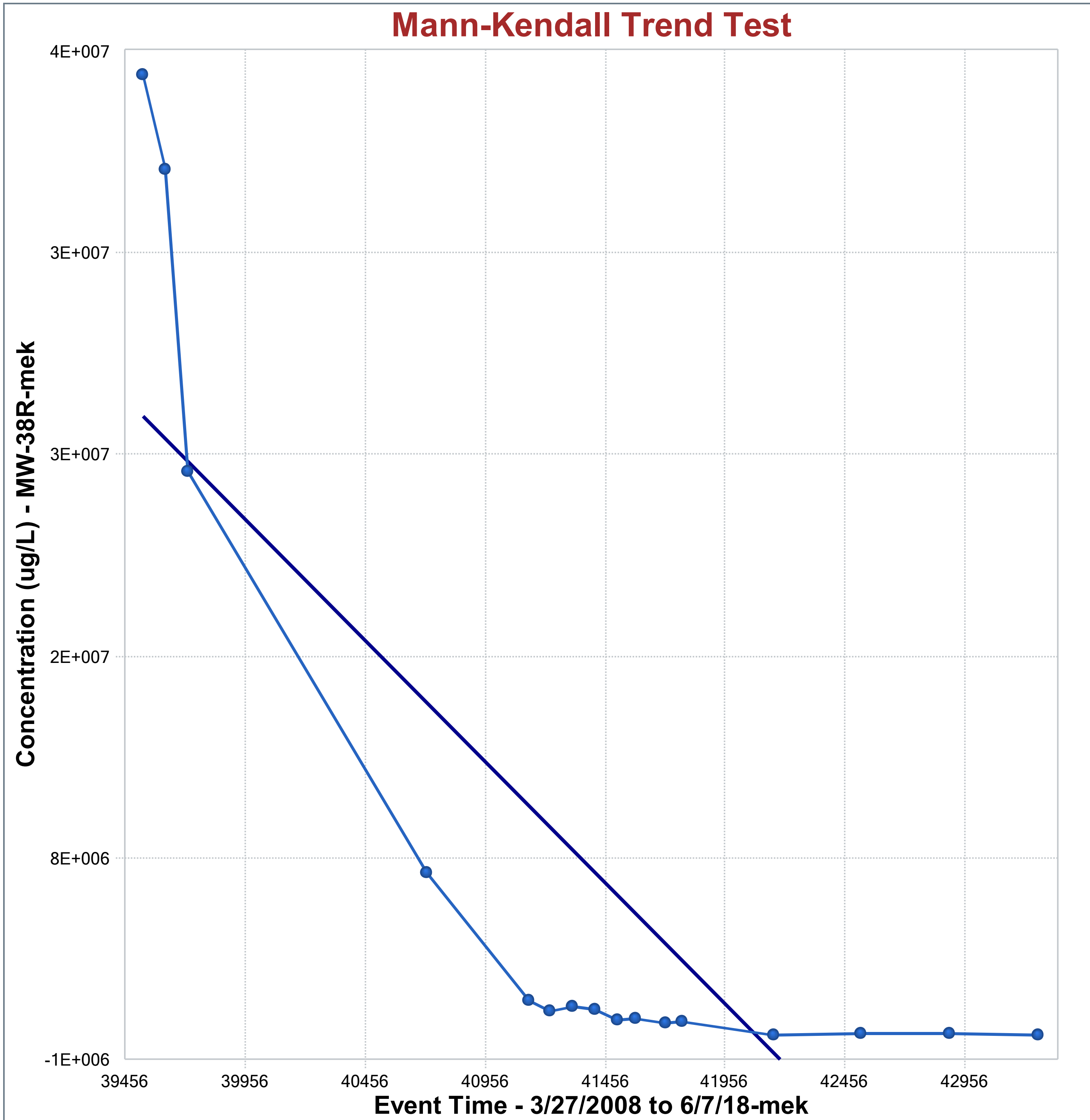
Number of Events Reported (m)	16
Number of Missing Events	0
Number or Reported Events Used	16
Number Values Reported (n)	16
Minimum	199000
Maximum	451000
Mean	338188
Geometric Mean	327907
Median	354500
Standard Deviation	81835

Coefficient of Variation	0.242

Mann-Kendall Test

M-K Test Value (S)	42
Tabulated p-value	0.032
Standard Deviation of S	22.21
Standardized Value of S	1.846
Approximate p-value	0.0325

Statistically significant evidence of an increasing
trend at the specified level of significance.



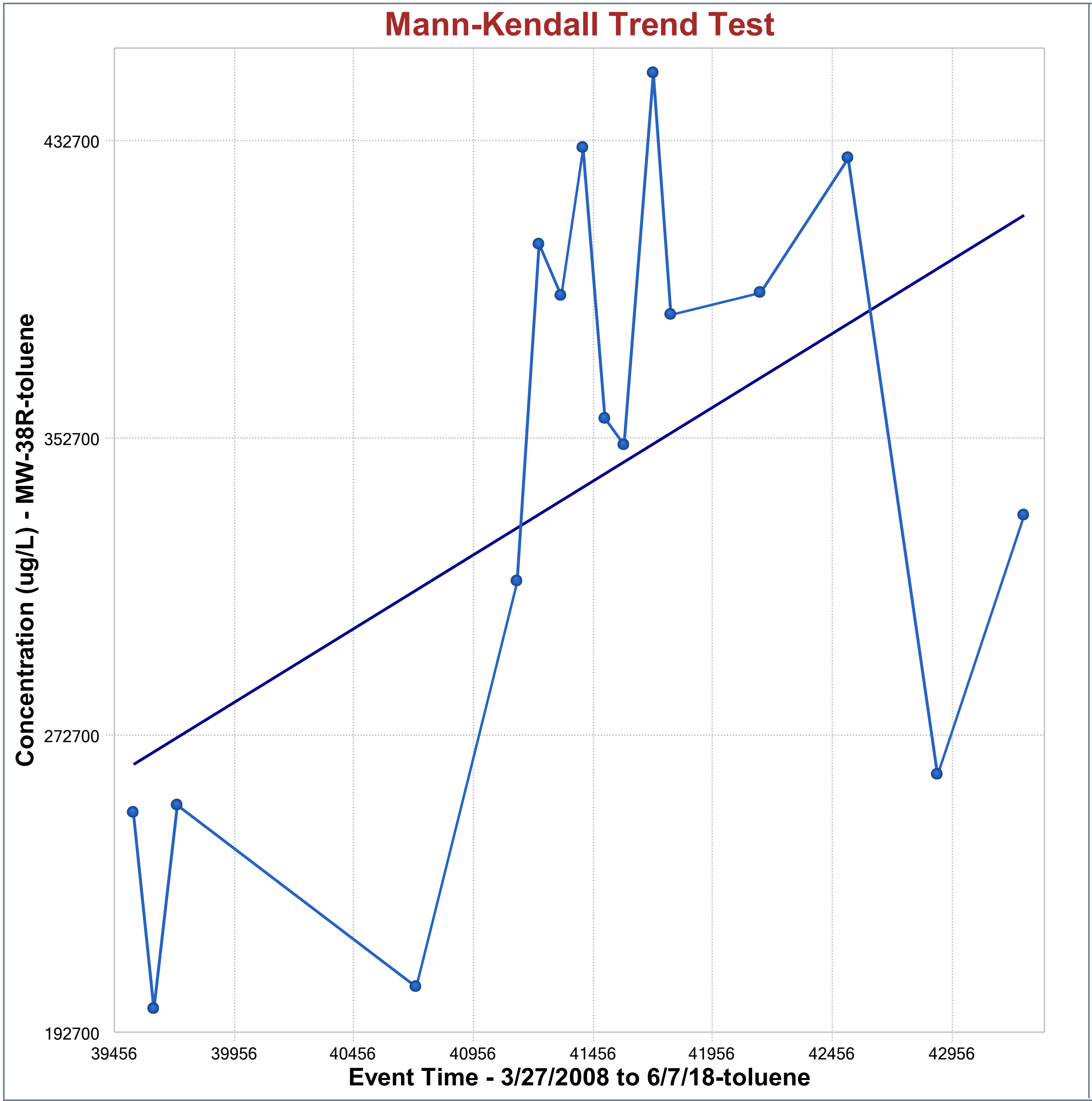
Mann-Kendall Trend Analysis

n	16
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	22.2111
Standardized Value of S	-4.7274
M-K Test Value (S)	-106
Tabulated p-value	0.0000
Approximate p-value	0.0000

OLS Regression Line (Blue)

OLS Regression Slope	-10,860.3680
OLS Regression Intercept	457,030,439.8055

Statistically significant evidence of a decreasing trend at the specified level of significance.



Mann-Kendall Trend Analysis

n	16
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	22.2111
Standardized Value of S	1.8459
M-K Test Value (S)	42
Tabulated p-value	0.0320
Approximate p-value	0.0325

OLS Regression Line (Blue)

OLS Regression Slope	39.6401
OLS Regression Intercept	-1,302,185.1693

Statistically significant evidence of an increasing trend at the specified level of significance.

MW-42

Mann-Kendall Trend Test Analysis

Mann-Kendall Trend Test Analysis

User Selected Options	
Date/Time of Computation	ProUCL 5.18/8/2018 3:38:57 PM
From File	MW-42 ProUCL Input.xls
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

Concentration (ug/L) - MW-42-mek

General Statistics

Number of Events Reported (m)	32
Number of Missing Events	0
Number or Reported Events Used	32
Number Values Reported (n)	32
Minimum	1.82
Maximum	3200
Mean	372.2
Geometric Mean	51.8
Median	50
Standard Deviation	785.5
Coefficient of Variation	2.111

Mann-Kendall Test

M-K Test Value (S)	32
Critical Value (0.05)	1.645
Standard Deviation of S	60.24
Standardized Value of S	0.515
Approximate p-value	0.303

Insufficient evidence to identify a significant trend at the specified level of significance.

Concentration (ug/L) - MW-42-toluene

General Statistics

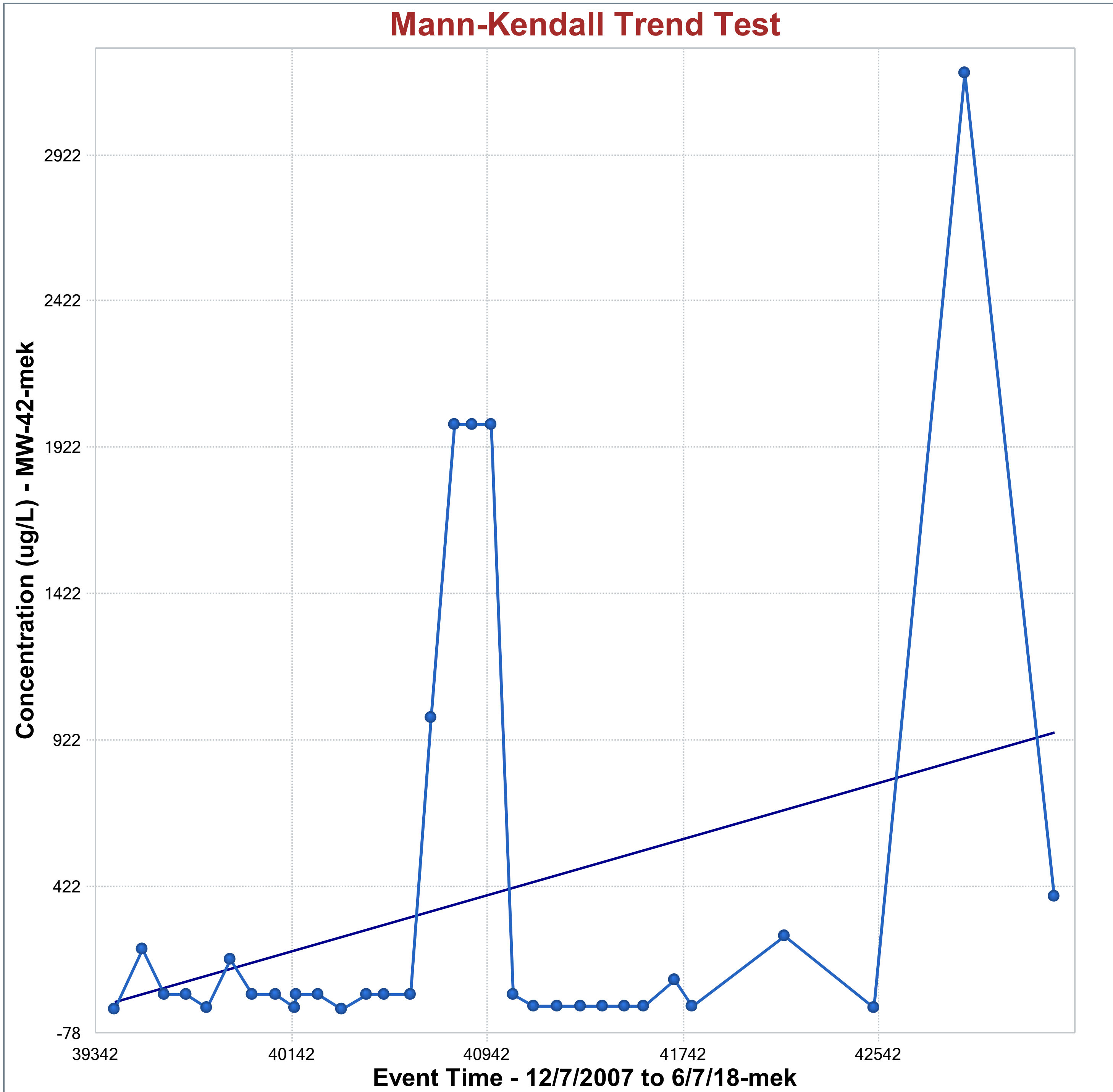
Number of Events Reported (m)	32
Number of Missing Events	0
Number or Reported Events Used	32
Number Values Reported (n)	32
Minimum	0.28
Maximum	118000
Mean	15674
Geometric Mean	79.66
Median	111.8
Standard Deviation	35804

Coefficient of Variation	2.284

Mann-Kendall Test

M-K Test Value (S)	114
Critical Value (0.05)	1.645
Standard Deviation of S	61.3
Standardized Value of S	1.843
Approximate p-value	0.0326

Statistically significant evidence of an increasing
trend at the specified level of significance.



Mann-Kendall Trend Analysis

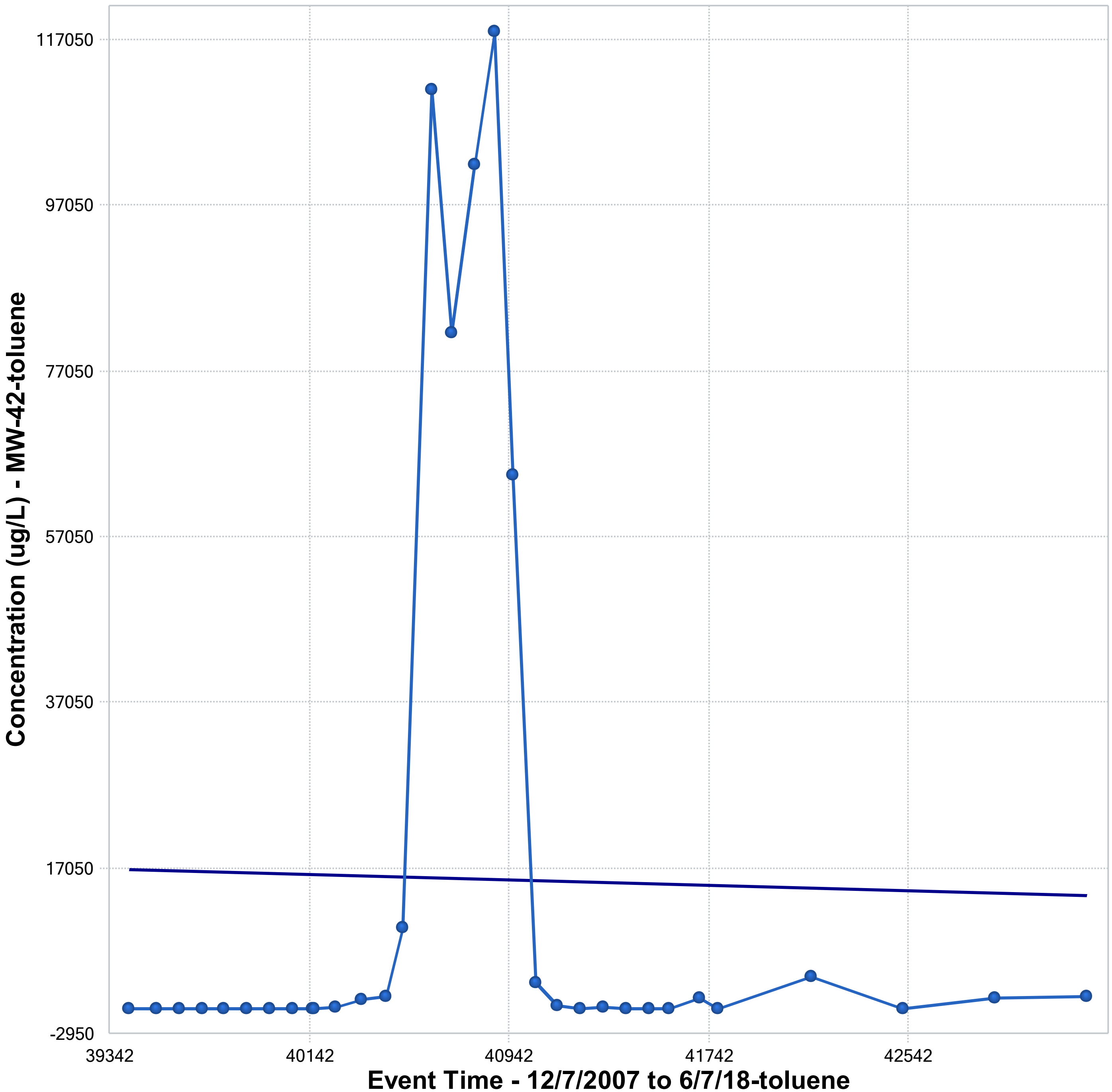
n	32
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	60.2384
Standardized Value of S	0.5146
M-K Test Value (S)	32
Appx. Critical Value (0.05)	1.6449
Approximate p-value	0.3034

OLS Regression Line (Blue)

OLS Regression Slope	0.2400
OLS Regression Intercept	-9,435.7400

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test



Mann-Kendall Trend Analysis

n	32
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	61.2971
Standardized Value of S	1.8435
M-K Test Value (S)	114
Appx. Critical Value (0.05)	1.6449
Approximate p-value	0.0326

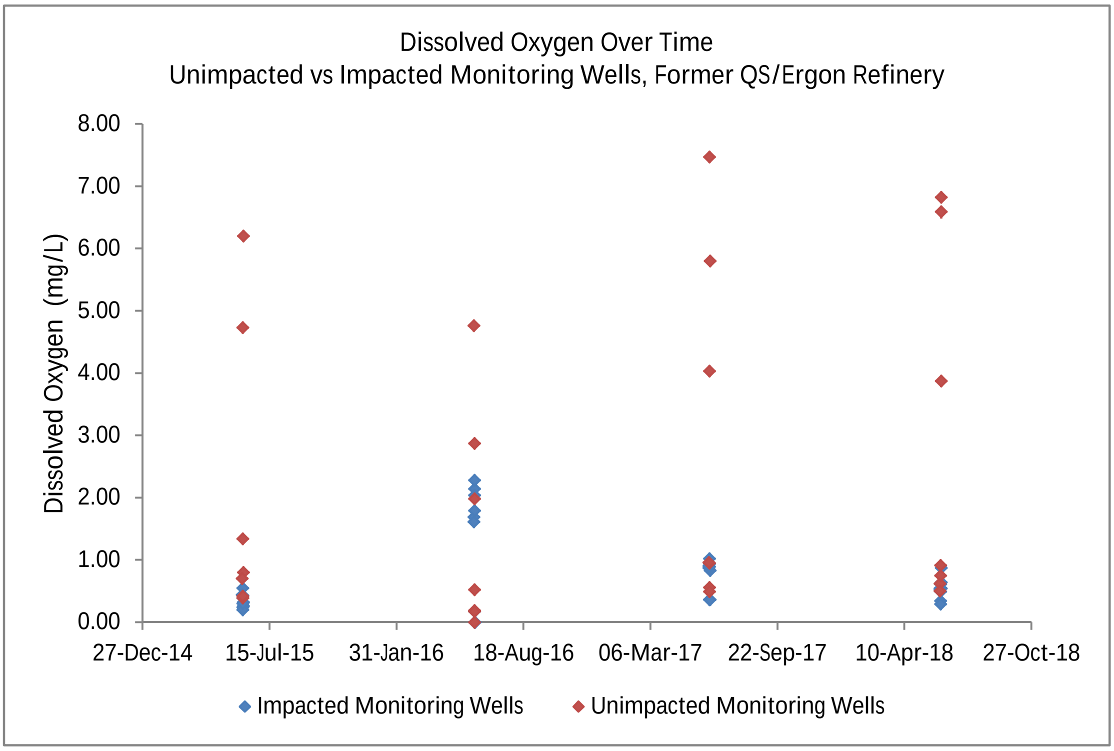
OLS Regression Line (Blue)

OLS Regression Slope	-0.8210
OLS Regression Intercept	49,217.8793

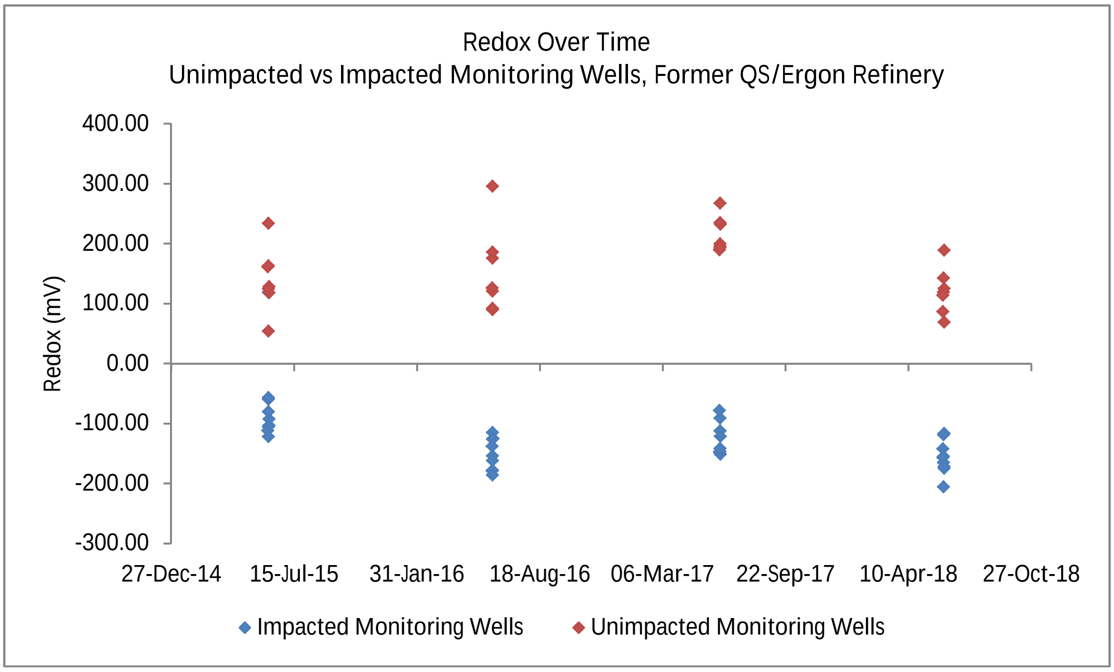
Statistically significant evidence of an increasing trend at the specified level of significance.

Appendix E

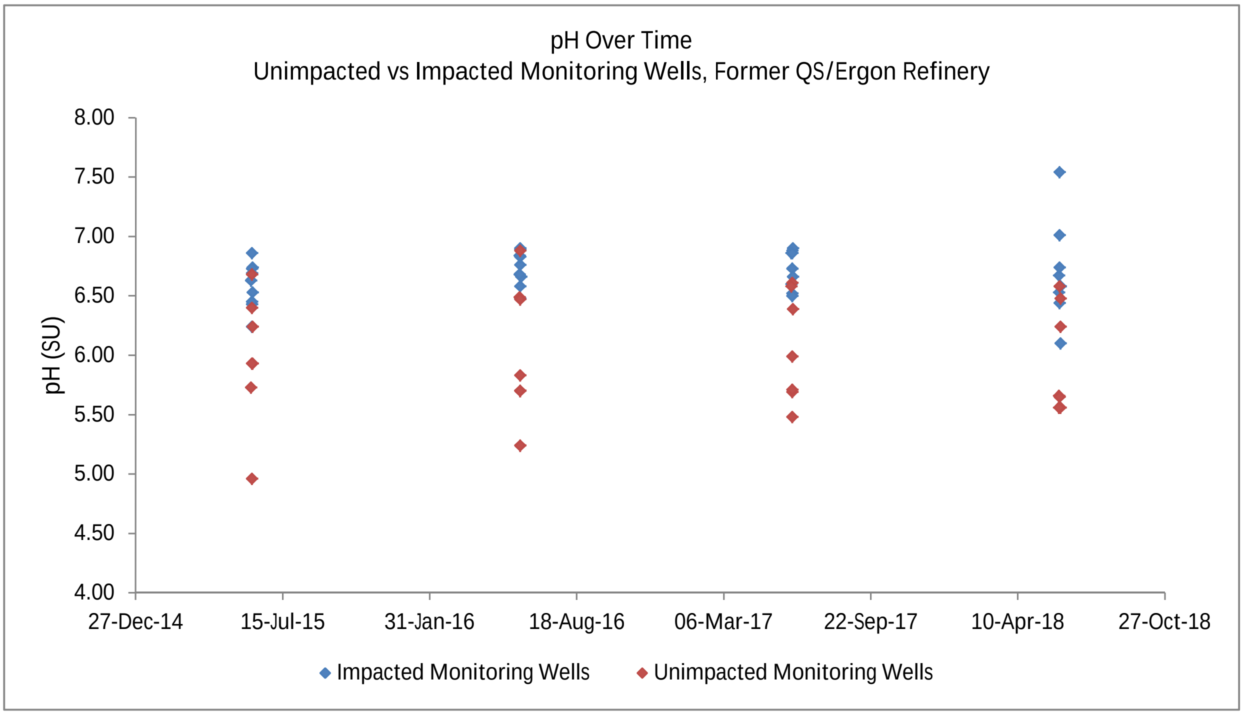
Natural Attenuation Parameter Graphs

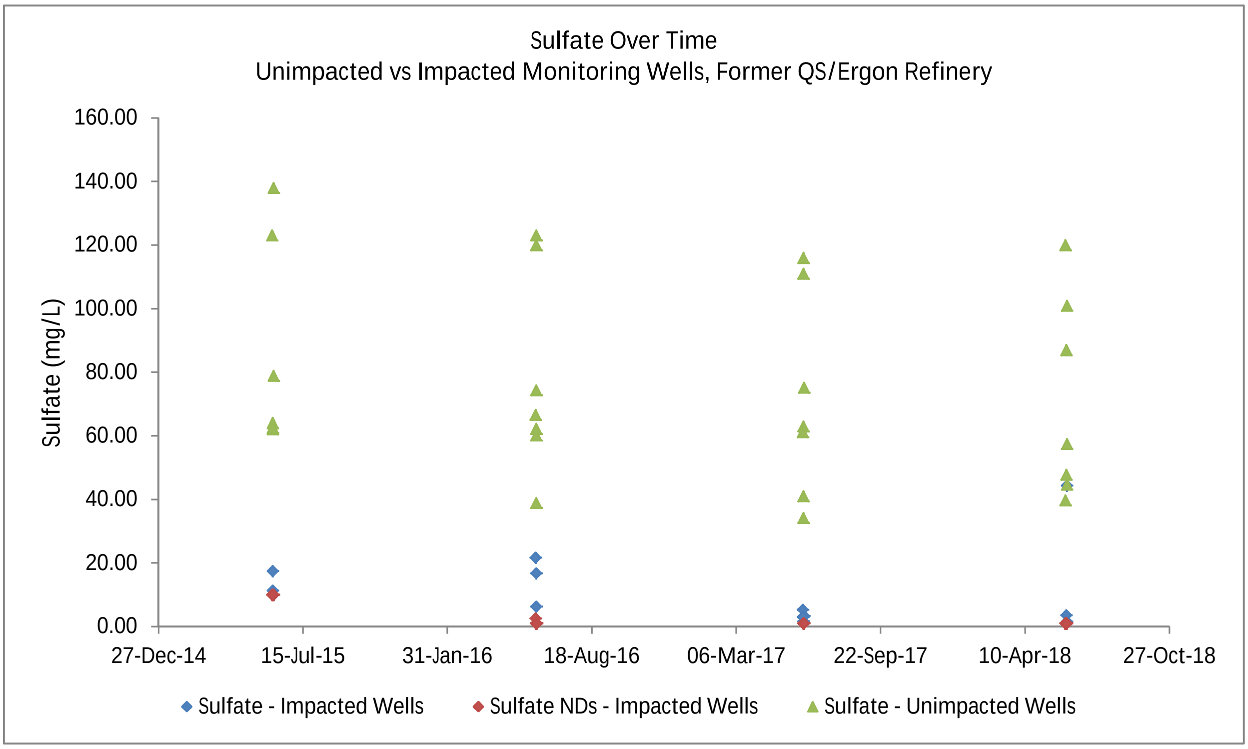


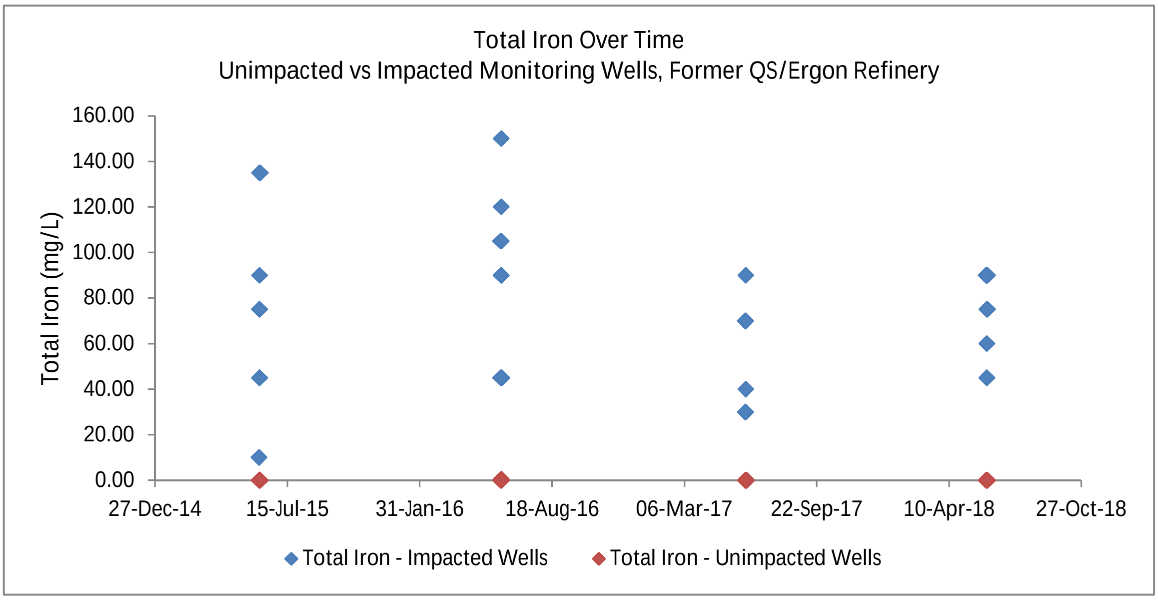
Dissolved Oxygen Over Time
Unimpacted vs Impacted Monitoring Wells, Former QS/Ergon Refinery
Dissolved Oxygen (mg/L)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
27-Dec-14
15-Jul-15
31-Jan-16
18-Aug-16
06-Mar-17
22-Sep-17
10-Apr-18
27-Oct-18
Impacted Monitoring Wells
Unimpacted Monitoring Wells

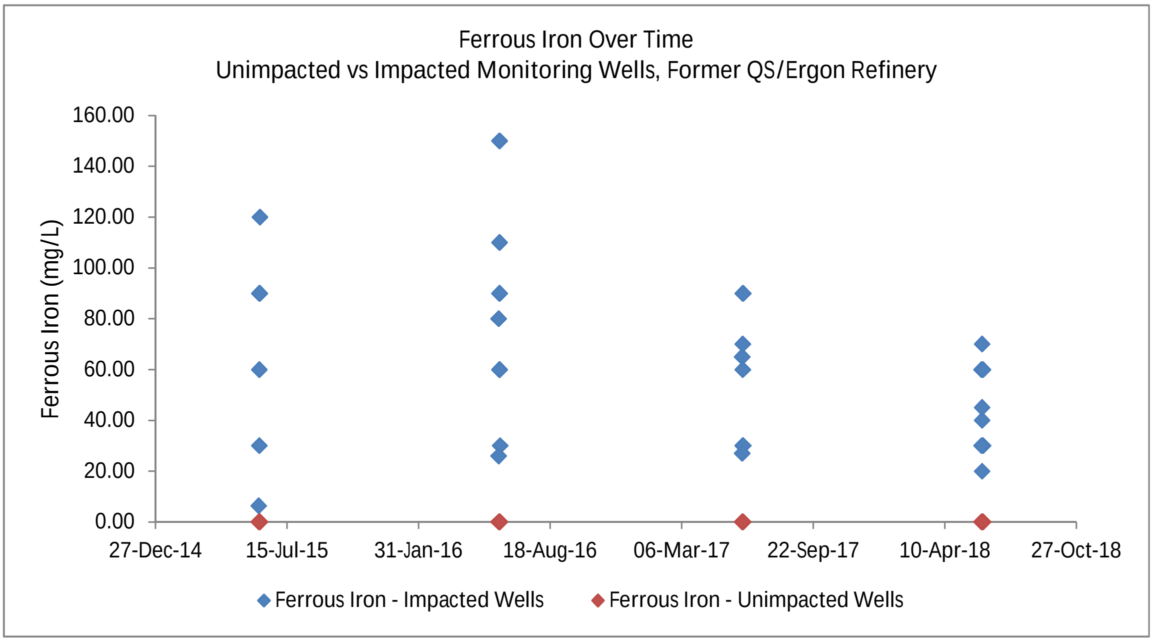


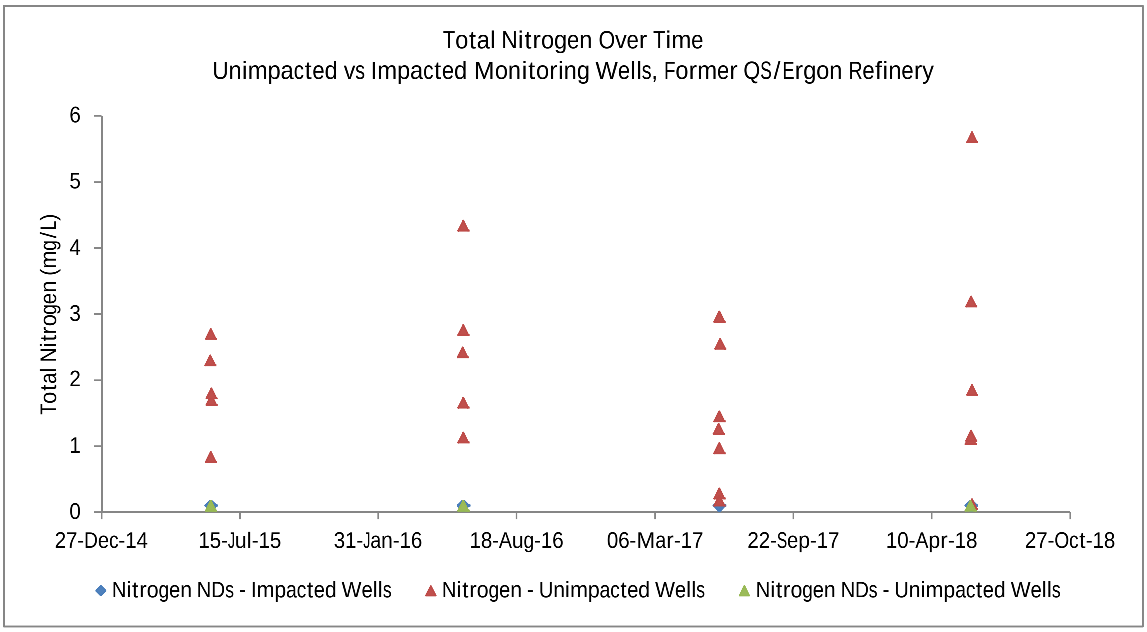
Redox Over Time
Unimpacted vs Impacted Monitoring Wells, Former QS/Ergon Refinery
Redox (mV)
400.00
300.00
200.00
100.00
0.00
-100.00
-200.00
-300.00
27-Dec-14
15-Jul-15
31-Jan-16
18-Aug-16
06-Mar-17
22-Sep-17
10-Apr-18
27-Oct-18
Impacted Monitoring Wells
Unimpacted Monitoring Wells

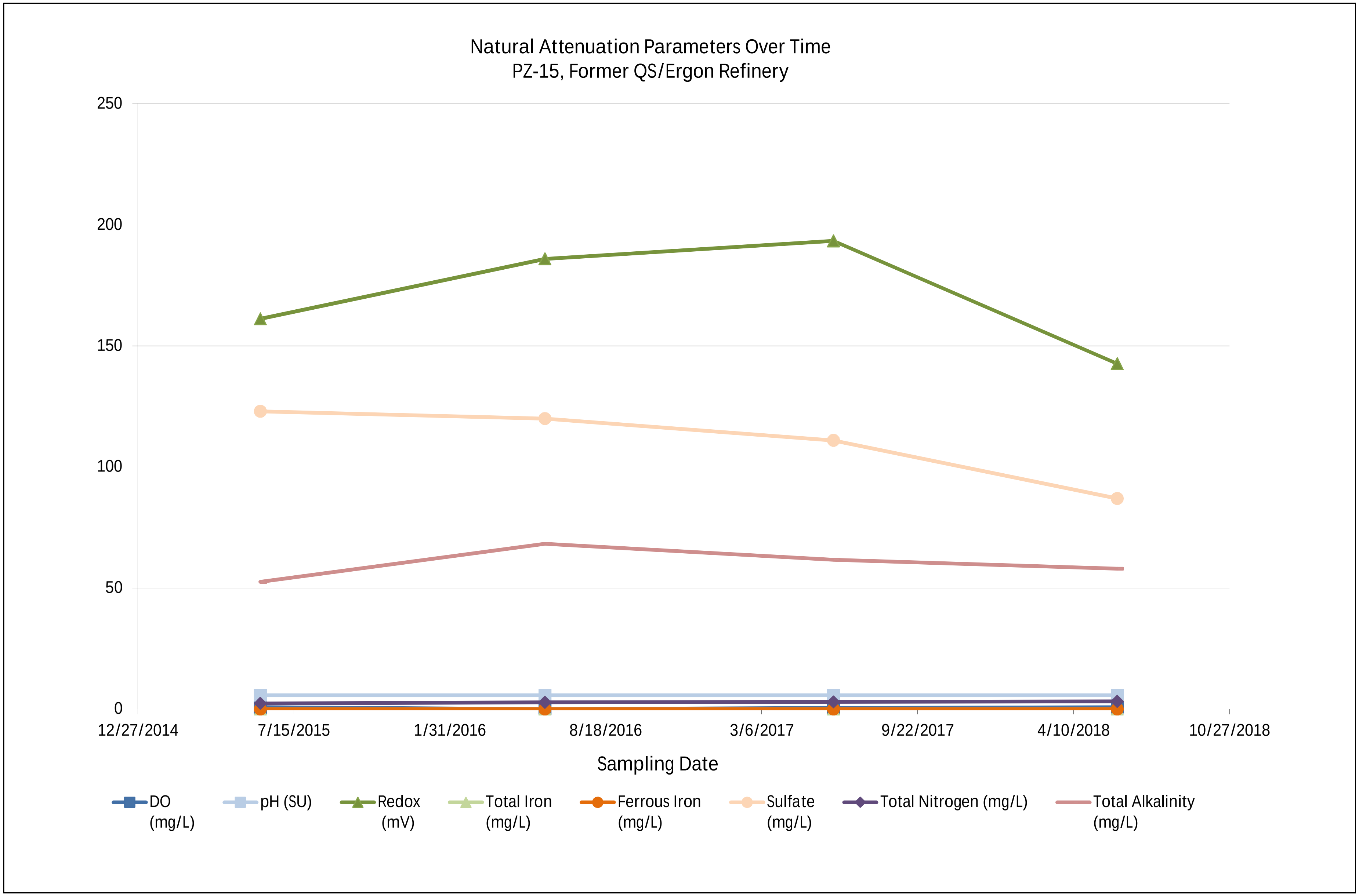

pH Over Time
Unimpacted vs Impacted Monitoring Wells, Former QS/Ergon Refinery
pH (SU)
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
27-Dec-14
15-Jul-15
31-Jan-16
18-Aug-16
06-Mar-17
22-Sep-17
10-Apr-18
27-Oct-18
Impacted Monitoring Wells
Unimpacted Monitoring Wells


Sulfate Over Time
Unimpacted vs Impacted Monitoring Wells, Former QS/Ergon Refinery
Sulfate (mg/L)
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
27-Dec-14
15-Jul-15
31-Jan-16
18-Aug-16
06-Mar-17
22-Sep-17
10-Apr-18
27-Oct-18
Sulfate - Impacted Wells
Sulfate NDs - Impacted Wells
Sulfate - Unimpacted Wells

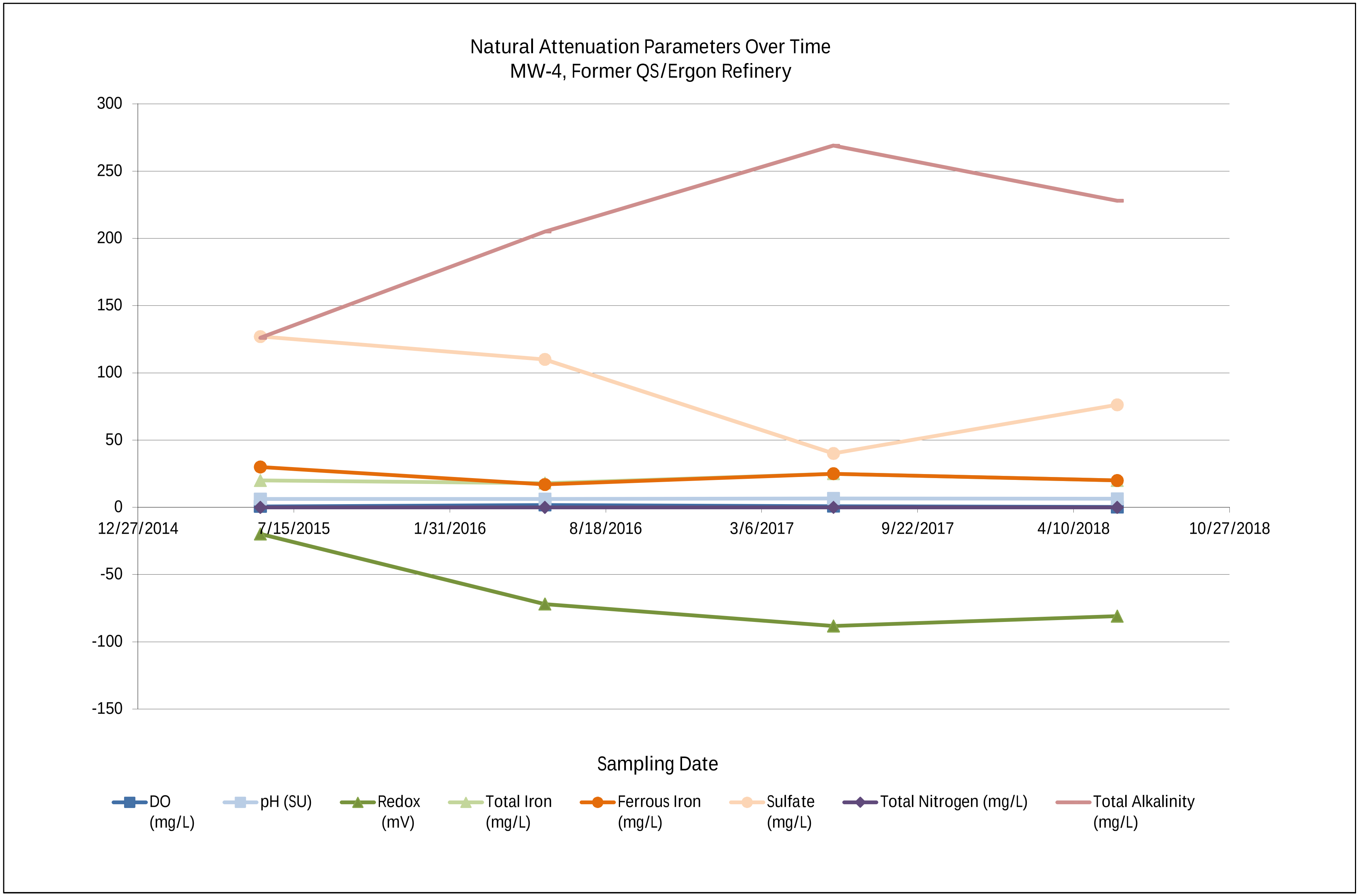

Total Iron Over Time
Unimpacted vs Impacted Monitoring Wells, Former QS/Ergon Refinery
Total Iron (mg/L)
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
27-Dec-14
15-Jul-15
31-Jan-16
18-Aug-16
06-Mar-17
22-Sep-17
10-Apr-18
27-Oct-18
Total Iron - Impacted Wells
Total Iron - Unimpacted Wells


Ferrous Iron Over Time
Unimpacted vs Impacted Monitoring Wells, Former QS/Ergon Refinery
Ferrous Iron (mg/L)
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
27-Dec-14
15-Jul-15
31-Jan-16
18-Aug-16
06-Mar-17
22-Sep-17
10-Apr-18
27-Oct-18
Ferrous Iron - Impacted Wells
Ferrous Iron - Unimpacted Wells

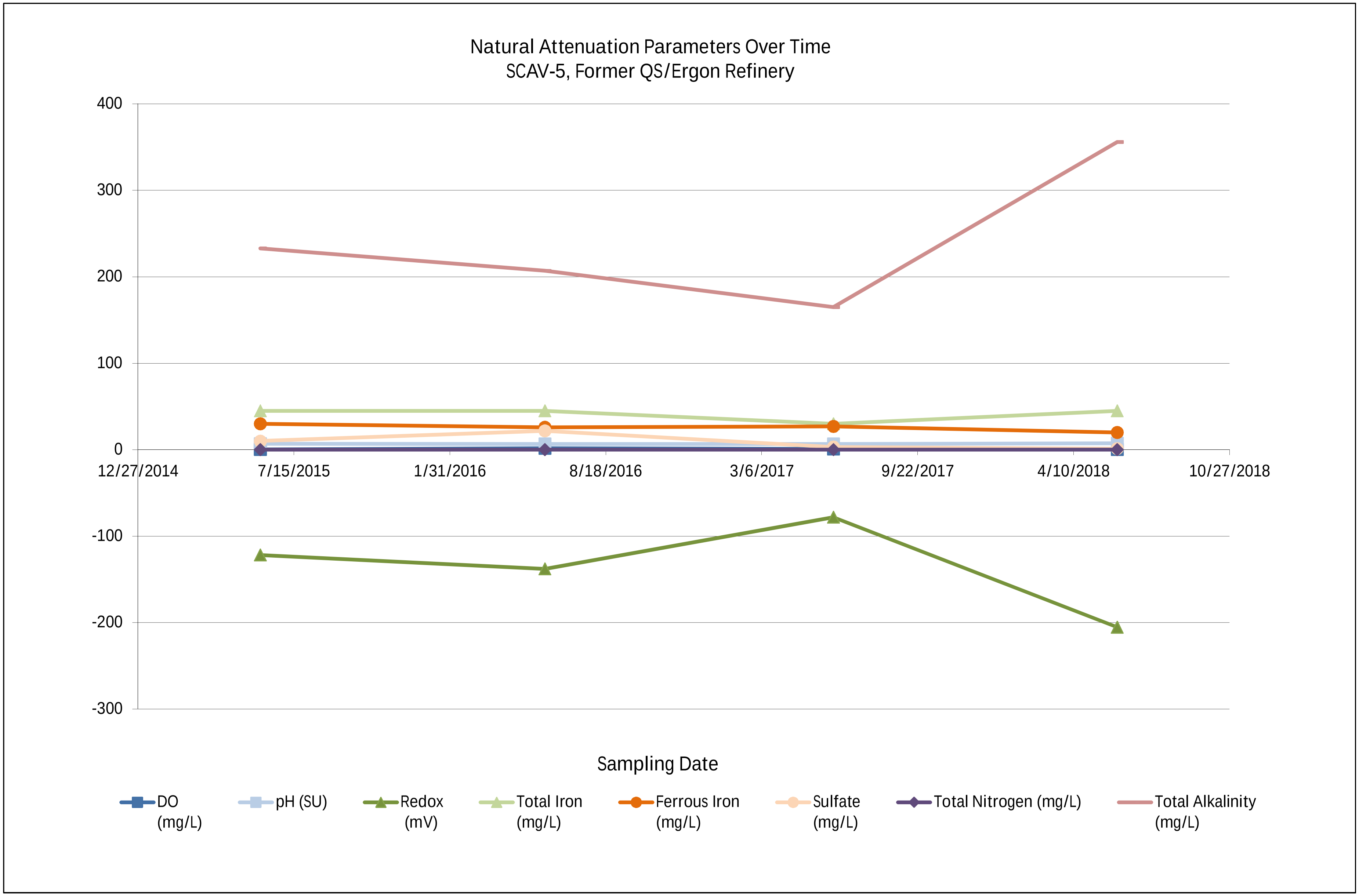

Total Nitrogen Over Time
Unimpacted vs Impacted Monitoring Wells, Former QS/Ergon Refinery
Total Nitrogen (mg/L)
6
5
4
3
2
1
0
27-Dec-14
15-Jul-15
31-Jan-16
18-Aug-16
06-Mar-17
22-Sep-17
10-Apr-18
27-Oct-18
Nitrogen NDs - Impacted Wells
Nitrogen - Unimpacted Wells
Nitrogen NDs - Unimpacted Wells



Natural Attenuation Parameters Over Time
PZ-15, Former QS/Ergon Refinery
250
200
150
100
50
0
12/27/2014
7/15/2015
1/31/2016
8/18/2016
3/6/2017
9/22/2017
4/10/2018
10/27/2018
Sampling Date
DO (mg/L)
pH (SU)
Redox (mV)
Total Iron (mg/L)
Ferrous Iron (mg/L)
Sulfate (mg/L)
Total Nitrogen (mg/L)
Total Alkalinity (mg/L)



Natural Attenuation Parameters Over Time
MW-4, Former QS/Ergon Refinery
300
250
200
150
100
50
0
-50
-100
-150
12/27/2014
7/15/2015
1/31/2016
8/18/2016
3/6/2017
9/22/2017
4/10/2018
10/27/2018
Sampling Date
DO (mg/L)
pH (SU)
Redox (mV)
Total Iron (mg/L)
Ferrous Iron (mg/L)
Sulfate (mg/L)
Total Nitrogen (mg/L)
Total Alkalinity (mg/L)



Natural Attenuation Parameters Over Time
SCAV-5, Former QS/Ergon Refinery
400
300
200
100
0
-100
-200
-300
12/27/2014
7/15/2015
1/31/2016
8/18/2016
3/6/2017
9/22/2017
4/10/2018
10/27/2018
Sampling Date
DO (mg/L)
pH (SU)
Redox (mV)
Total Iron (mg/L)
Ferrous Iron (mg/L)
Sulfate (mg/L)
Total Nitrogen (mg/L)
Total Alkalinity (mg/L)

Appendix F

SPL Footprint Maps from 2013 to 2018 and SPL Thickness Trend Graphs

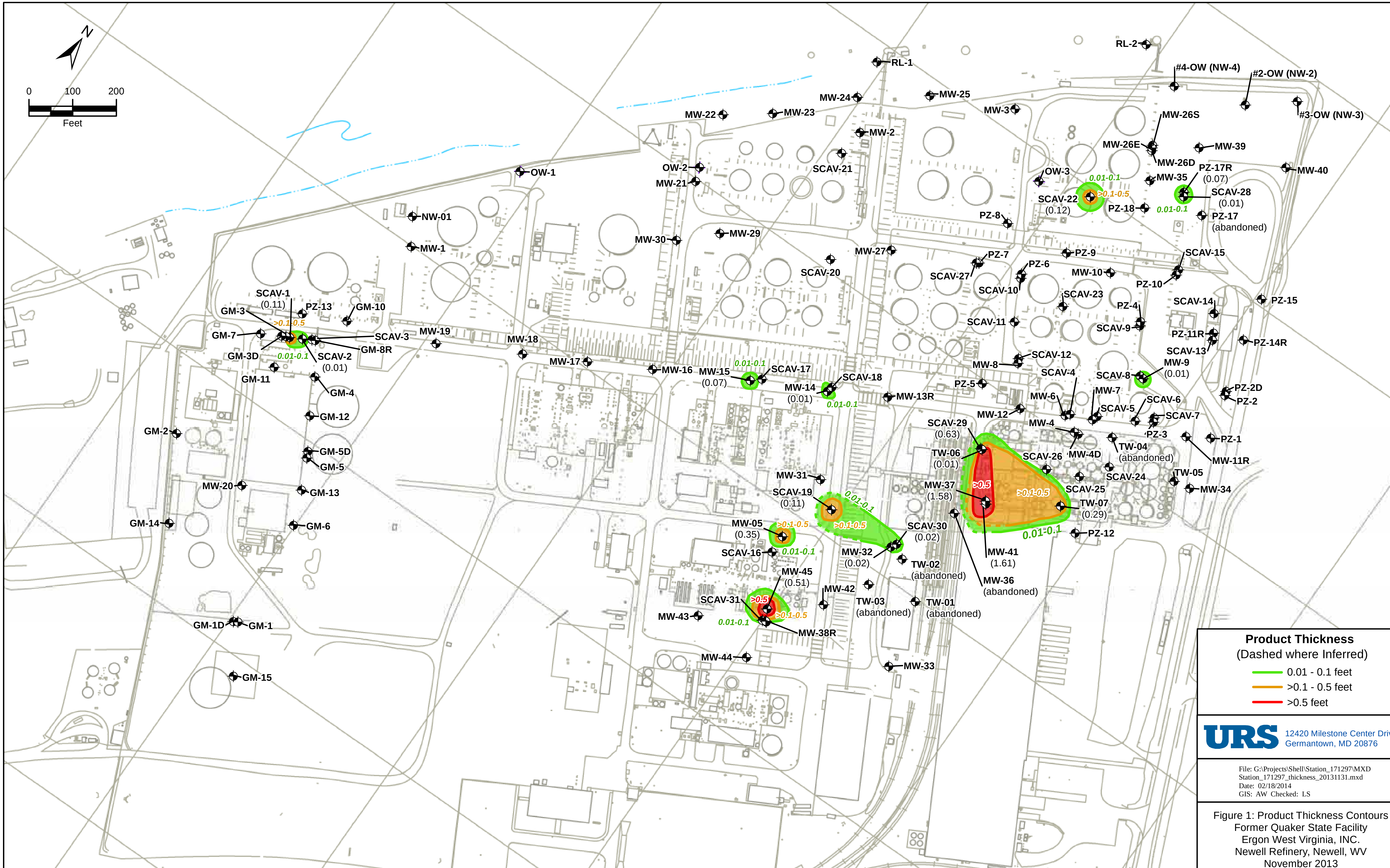


Figure 1: Product Thickness Contours
Former Quaker State Facility
Ergon West Virginia, INC.
Newell Refinery, Newell, WV
November 2013

AECOM 12420 Milestone Center Drive
Germantown, MD 20876

File:Q:\Projects\TechSol\GIS\Projects\Shell\Station_171297\MXD\Station_171297_SPLThickness_June2015_v10.0.mxd
Date: 09/21/2015
GIS: AB Checked: CC

Figure 2
SPL Thickness - June 2015
Former Quaker State/Ergon Refinery
Newell, West Virginia

Legend

- Monitoring Well
- Production Well
- (0.34) Measured SPL Thickness (ft)

SPL Thickness

- 0.01 - 0.1 feet
- >0.1 - 0.5 feet
- >0.5 feet

Note: All site wells were gauged for SPL. No actual measurement at a well indicates that no measureable SPL was noted in well.

AECOM 12420 Milestone Center Drive
Germantown, MD 20876

File:Q:\Projects\TechSol\GIS\Projects\Shell\Station_171297\MXD\Station_171297_SPLThickness_June2016.mxd
Date: 06/29/2016
GIS: MS Checked: KL

Figure 3
SPL Thickness
May 31, 2016
Former Quaker State/Ergon Refinery
Newell, West Virginia

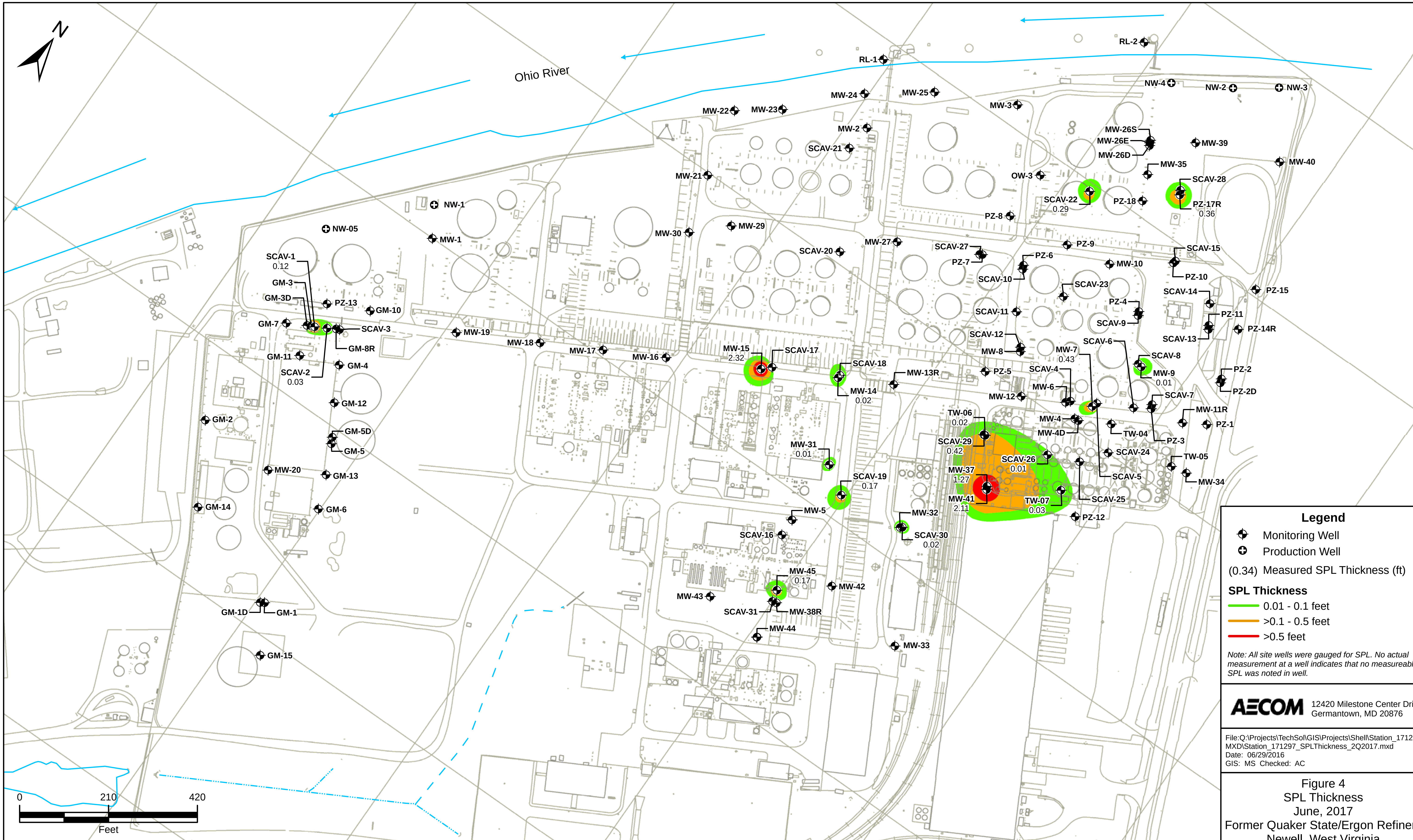
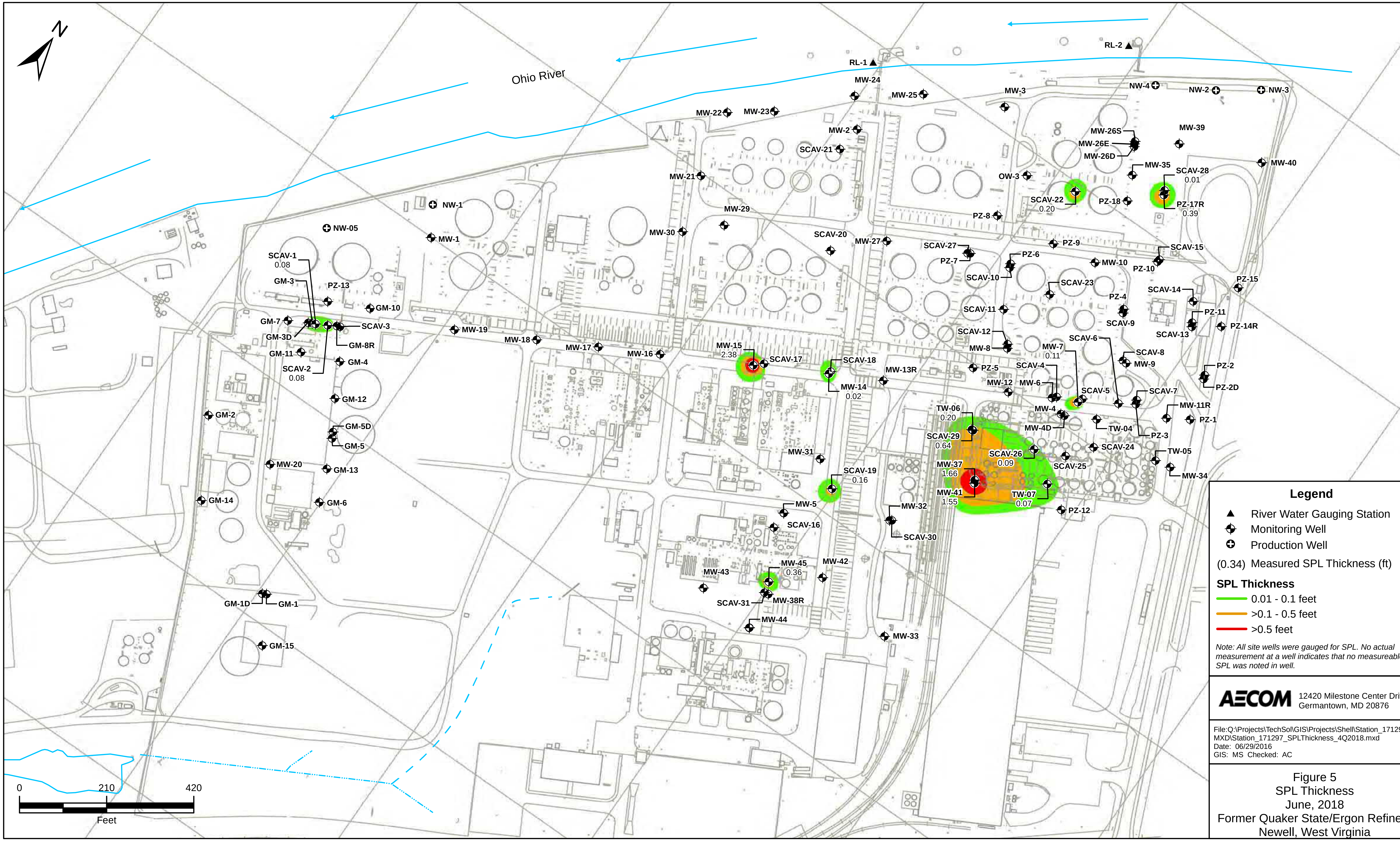
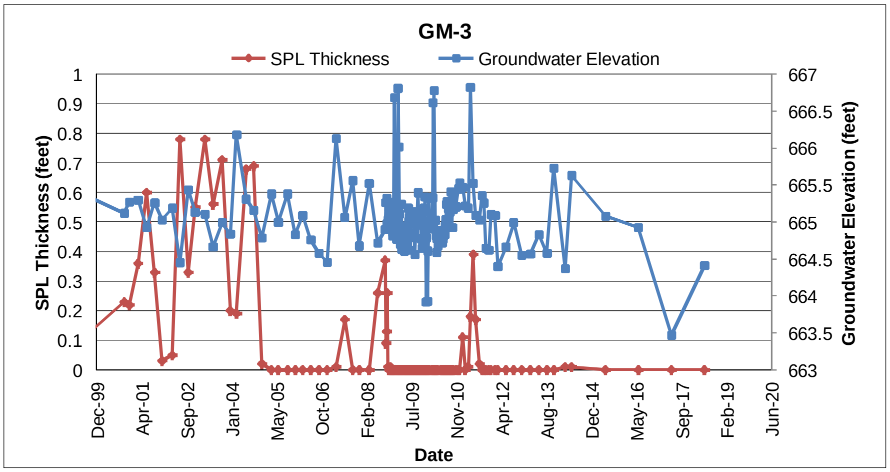
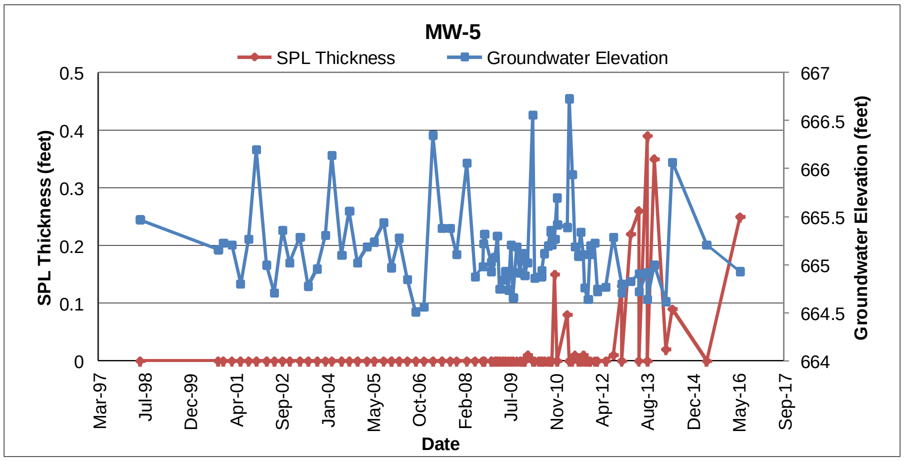
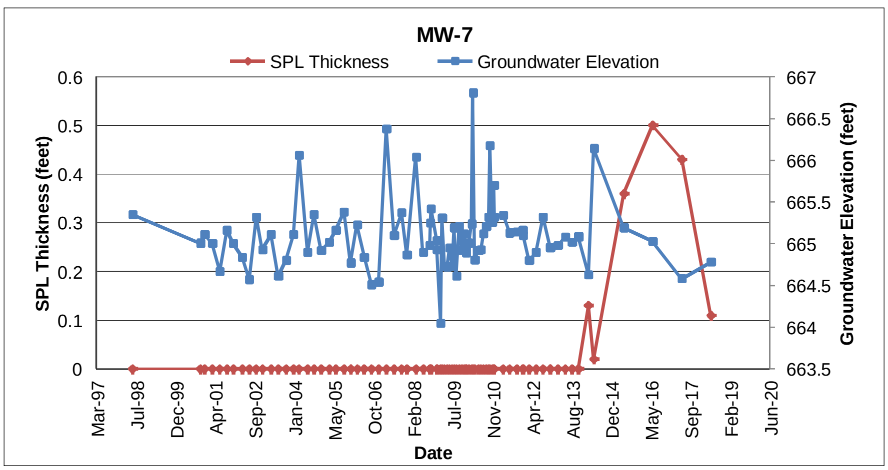


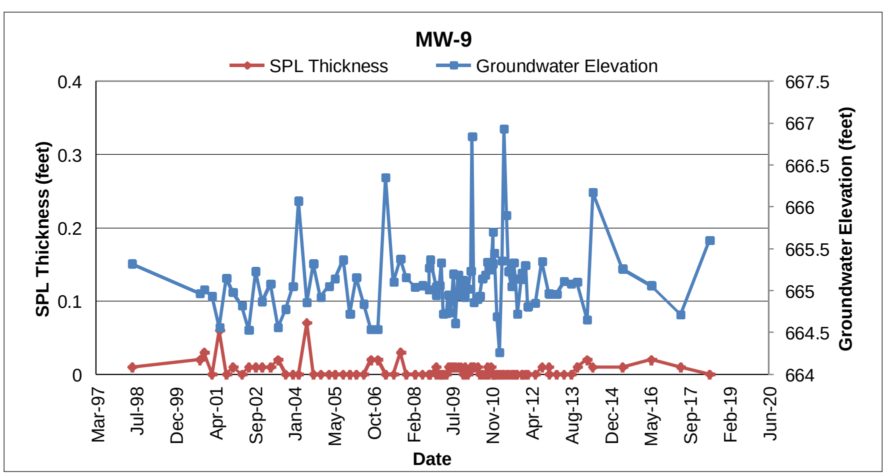
Figure 4
SPL Thickness
June, 2017
Former Quaker State/Ergon Refinery
Newell, West Virginia

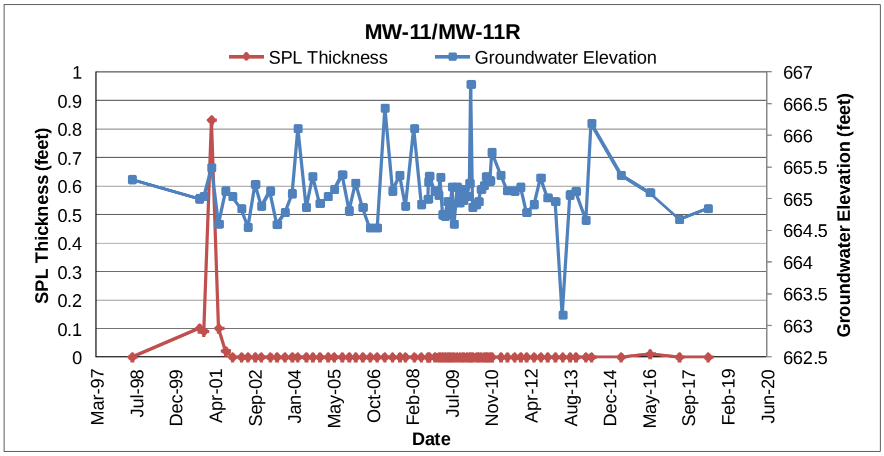

N
Ohio River
RL-1
RL-2
MW-24
MW-25
MW-3
NW-4
NW-2
NW-3
MW-22
MW-23
MW-2
MW-26S
MW-26E
MW-26D
MW-39
MW-40
SCAV-21
MW-21
OW-3
MW-35
SCAV-28
0.01
SCAV-22
0.20
PZ-18
PZ-17R
0.39
NW-1
MW-29
PZ-8
NW-05
MW-30
SCAV-20
MW-27
SCAV-27
PZ-9
SCAV-15
MW-1
PZ-6
MW-10
PZ-7
PZ-10
SCAV-1
0.08
SCAV-10
SCAV-23
PZ-15
GM-3
PZ-13
SCAV-14
PZ-4
GM-10
SCAV-11
PZ-11
GM-7
SCAV-3
MW-19
SCAV-9
PZ-14R
GM-3D
GM-8R
MW-18
SCAV-12
SCAV-13
MW-17
MW-15
2.38
MW-8
SCAV-6
GM-11
MW-16
MW-7
0.11
SCAV-8
SCAV-17
SCAV-18
MW-9
SCAV-2
0.08
GM-4
MW-13R
PZ-5
SCAV-4
PZ-2
MW-14
0.02
MW-12
MW-6
PZ-2D
SCAV-5
SCAV-7
GM-12
TW-06
0.20
MW-4
MW-11R
GM-2
PZ-1
GM-5D
MW-4D
TW-04
SCAV-29
0.64
PZ-3
GM-5
SCAV-24
SCAV-26
0.09
TW-05
MW-31
MW-20
MW-37
1.66
SCAV-25
GM-13
SCAV-19
0.16
MW-34
MW-41
1.55
TW-07
0.07
GM-14
GM-6
MW-5
MW-32
PZ-12
SCAV-16
SCAV-30
MW-45
0.36
MW-42
MW-43
GM-1D
GM-1
SCAV-31
MW-38R
MW-44
MW-33
GM-15
0
210
420
Feet
Legend
River Water Gauging Station
Monitoring Well
Production Well
(0.34) Measured SPL Thickness (ft)
SPL Thickness
0.01 - 0.1 feet
>0.1 - 0.5 feet
>0.5 feet
Note: All site wells were gauged for SPL. No actual measurement at a well indicates that no measureable SPL was noted in well.
AECOM
12420 Milestone Center Drive
Germantown, MD 20876
File:Q:\Projects\TechSol\GIS\Projects\Shell\Station_171297\MXD\Station_171297_SPLThickness_4Q2018.mxd
Date: 06/29/2016
GIS: MS Checked: AC
Figure 5
SPL Thickness
June, 2018
Former Quaker State/Ergon Refinery
Newell, West Virginia

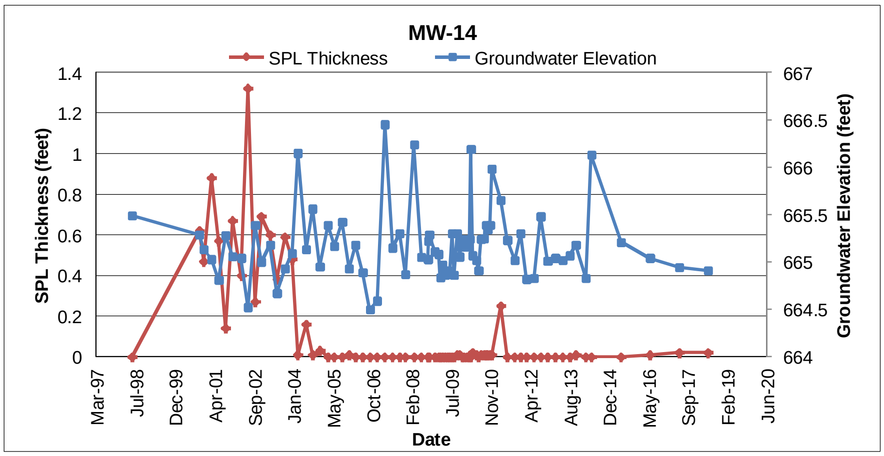

GM-3
SPL Thickness
Groundwater Elevation
SPL Thickness (feet)
Groundwater Elevation (feet)
Date
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20

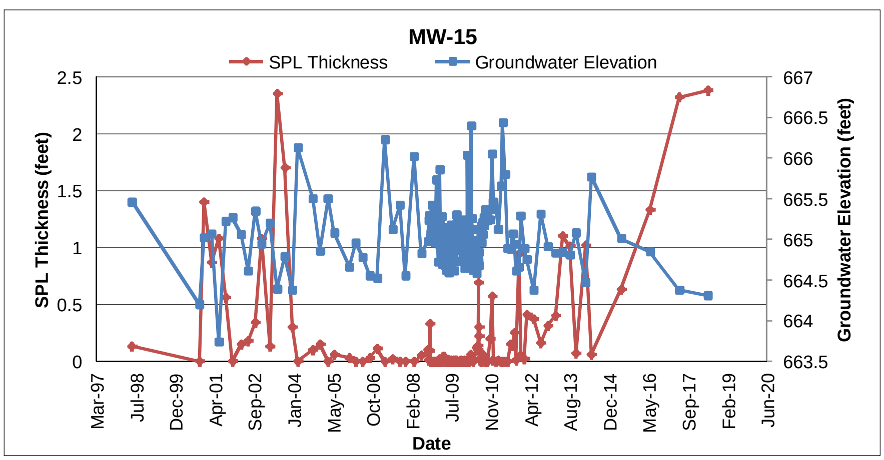

MW-5
SPL Thickness
Groundwater Elevation
SPL Thickness (feet)
Groundwater Elevation (feet)
Date
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17

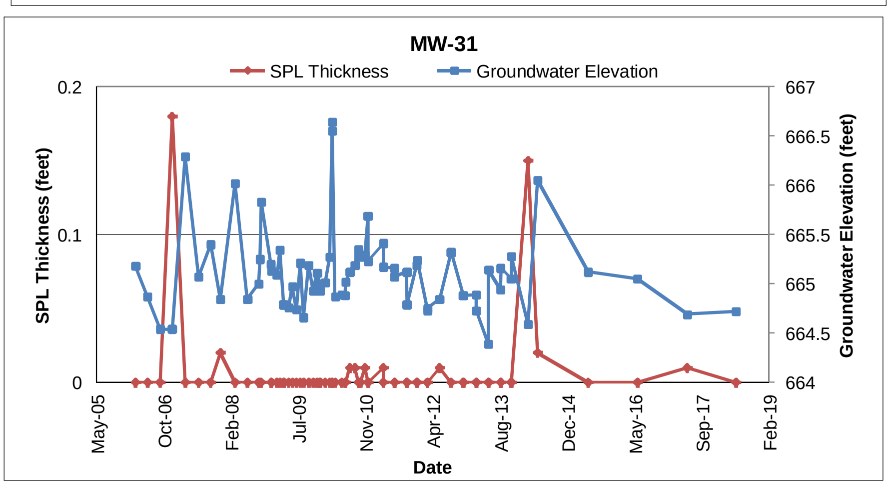

MW-7
SPL Thickness
Groundwater Elevation
SPL Thickness (feet)
Groundwater Elevation (feet)
Date
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20

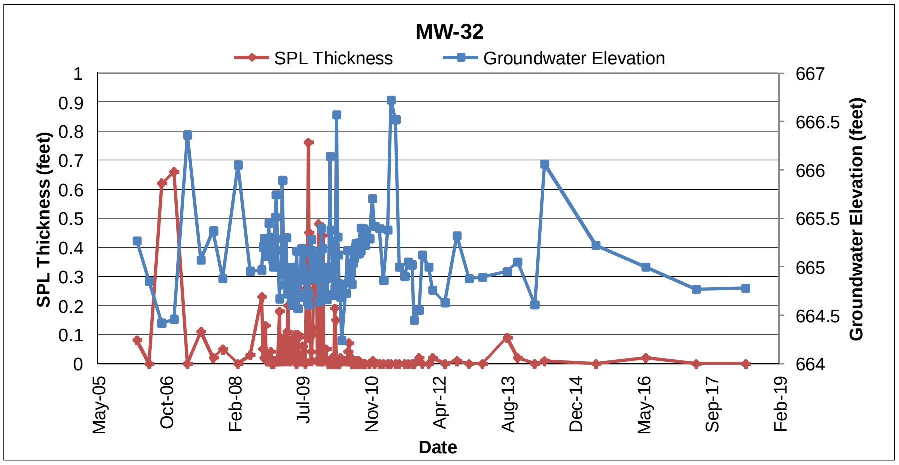

MW-9
SPL Thickness
Groundwater Elevation
SPL Thickness (feet)
Groundwater Elevation (feet)
Date
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20


MW-11/MW-11R
SPL Thickness
Groundwater Elevation
SPL Thickness (feet)
Groundwater Elevation (feet)
Date
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
667
666.5
666
665.5
665
664.5
664
663.5
663
662.5
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20

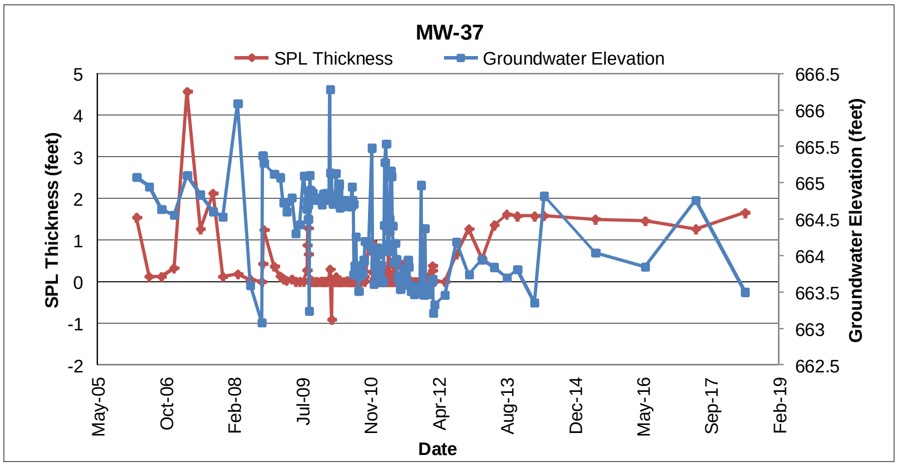

MW-14
SPL Thickness
Groundwater Elevation
SPL Thickness (feet)
Groundwater Elevation (feet)
Date
1.4
1.2
1
0.8
0.6
0.4
0.2
0
667
666.5
666
665.5
665
664.5
664
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20


MW-15
SPL Thickness
Groundwater Elevation
SPL Thickness (feet)
Groundwater Elevation (feet)
Date
2.5
2
1.5
1
0.5
0
667
666.5
666
665.5
665
664.5
664
663.5
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20

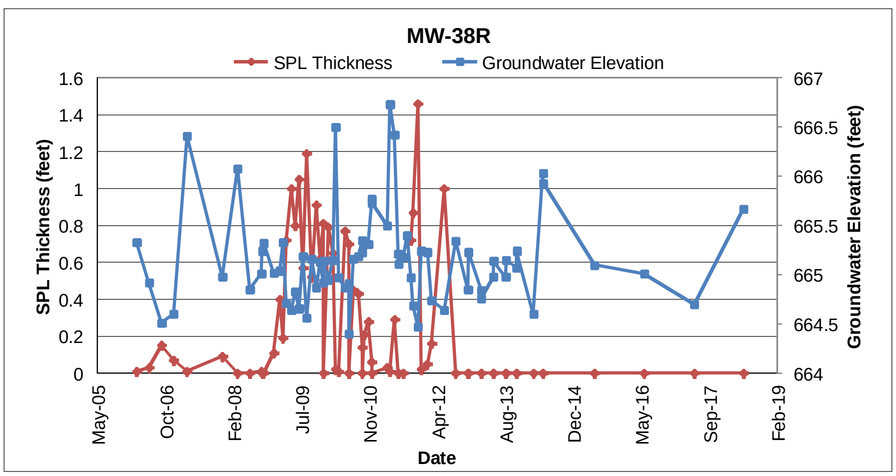

MW-31
SPL Thickness
Groundwater Elevation
SPL Thickness (feet)
Groundwater Elevation (feet)
Date
0.2
0.1
0
667
666.5
666
665.5
665
664.5
664
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19



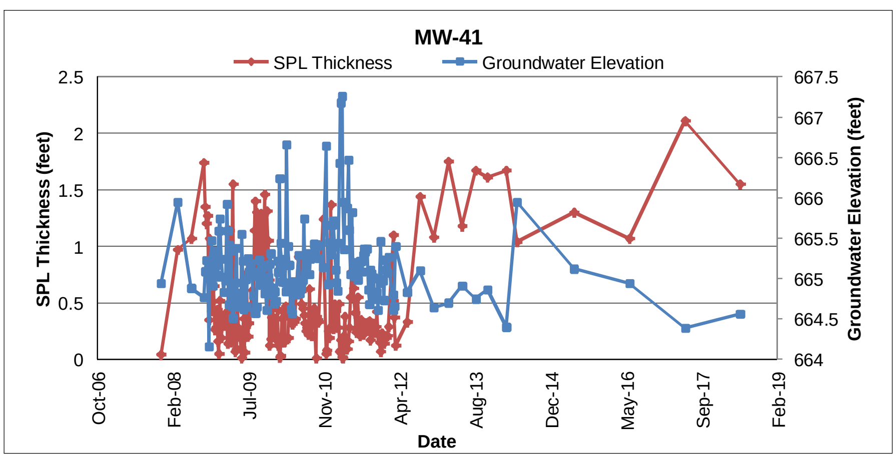
MW-32
SPL Thickness
Groundwater Elevation
SPL Thickness (feet)
Groundwater Elevation (feet)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
667
666.5
666
665.5
665
664.5
664
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Date



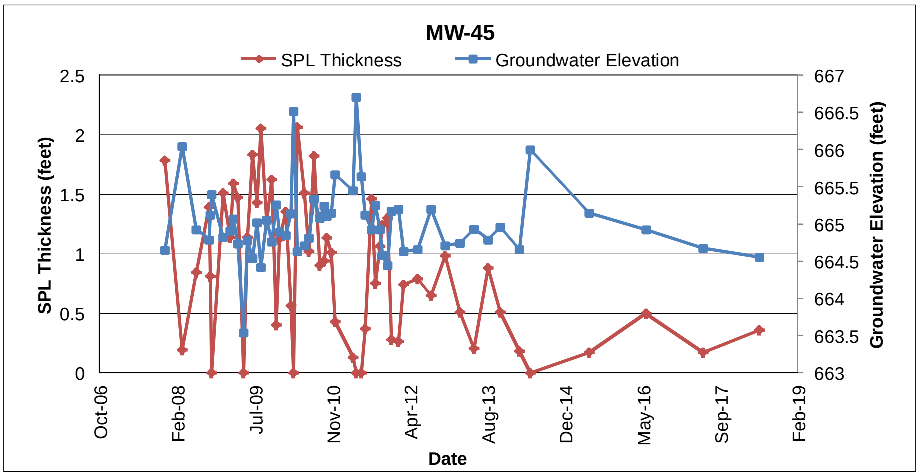
MW-37
SPL Thickness
Groundwater Elevation
SPL Thickness (feet)
Groundwater Elevation (feet)
5
4
3
2
1
0
-1
-2
666.5
666
665.5
665
664.5
664
663.5
663
662.5
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Date



MW-38R
SPL Thickness
Groundwater Elevation
SPL Thickness (feet)
Groundwater Elevation (feet)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
667
666.5
666
665.5
665
664.5
664
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Date



MW-41
SPL Thickness
Groundwater Elevation
SPL Thickness (feet)
Groundwater Elevation (feet)
2.5
2
1.5
1
0.5
0
667.5
667
666.5
666
665.5
665
664.5
664
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Date



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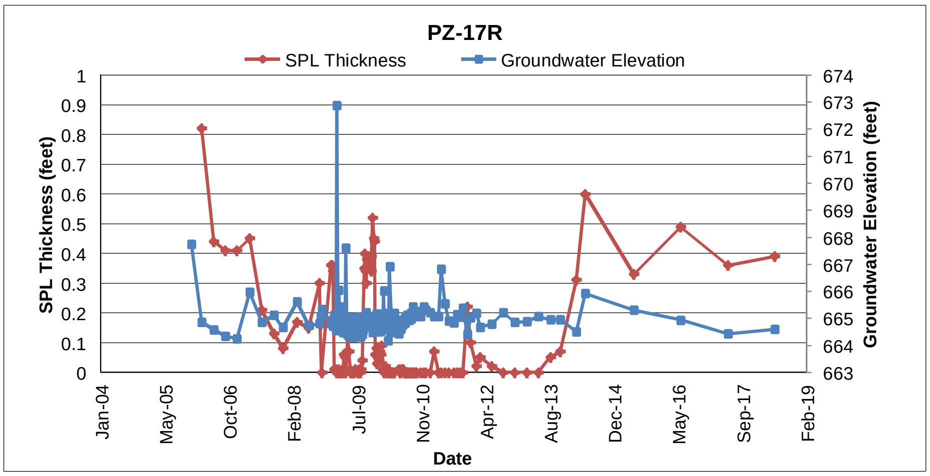
Feb-19



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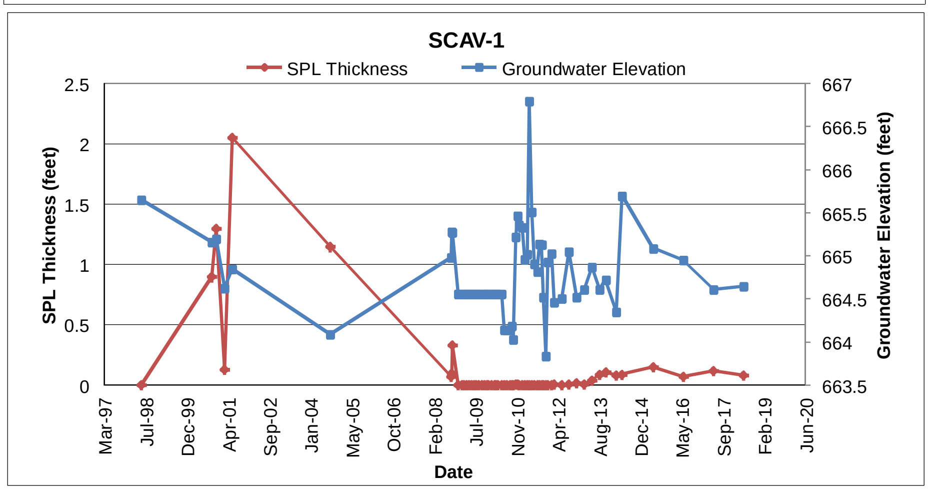

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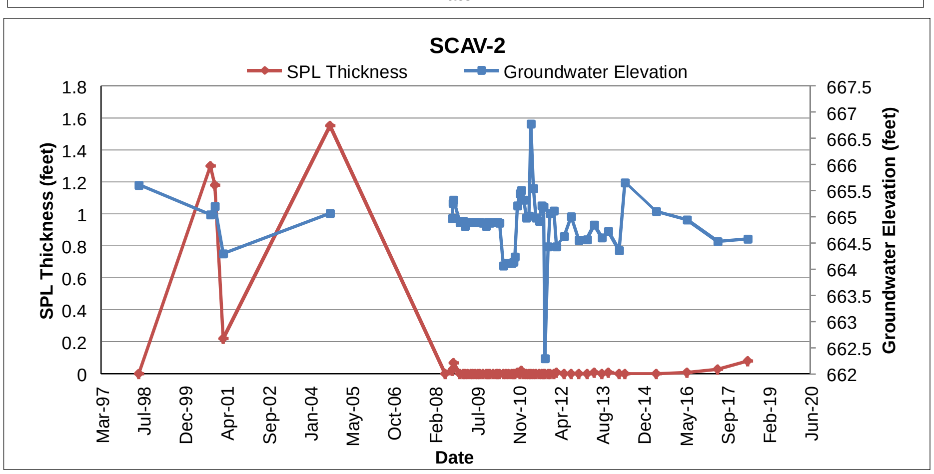

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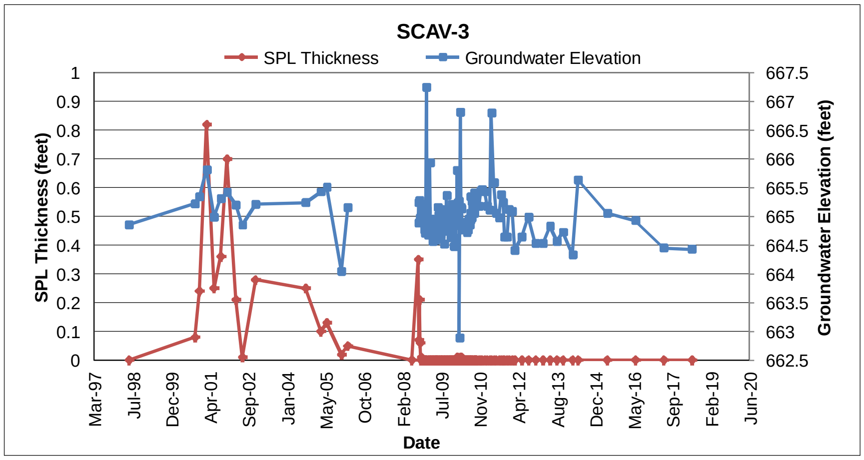
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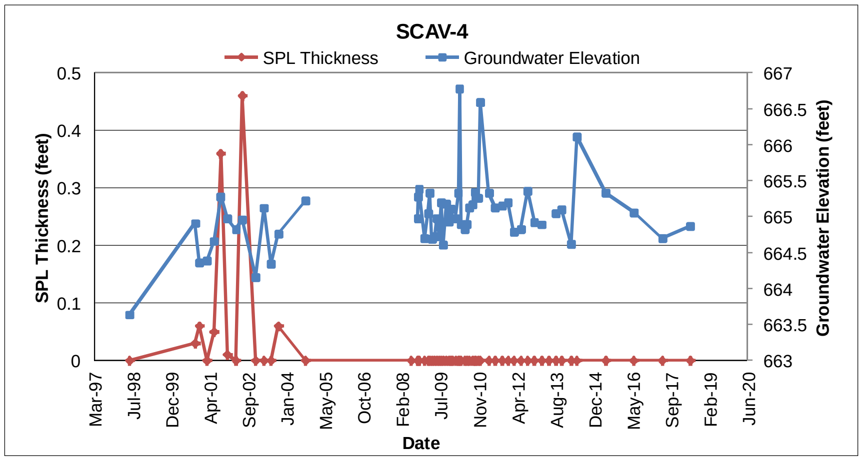
Jun-20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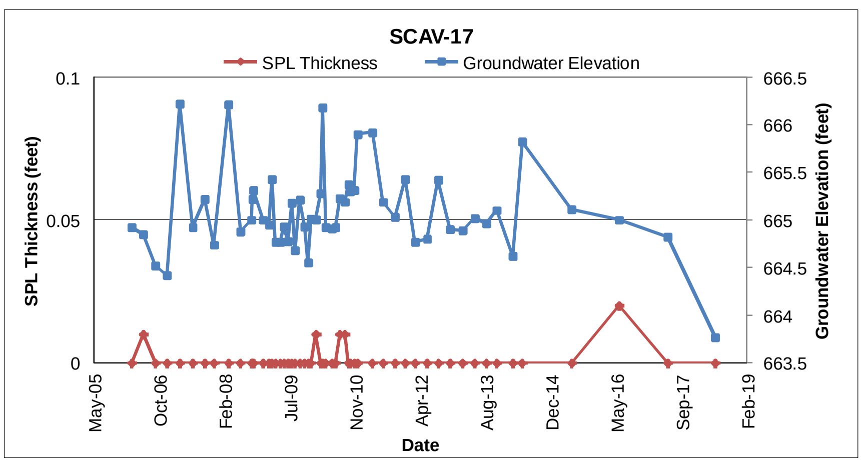
Jun-20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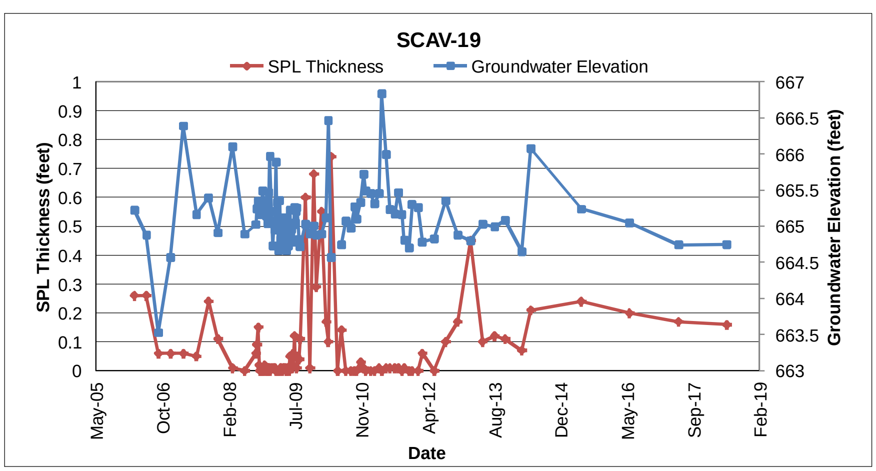
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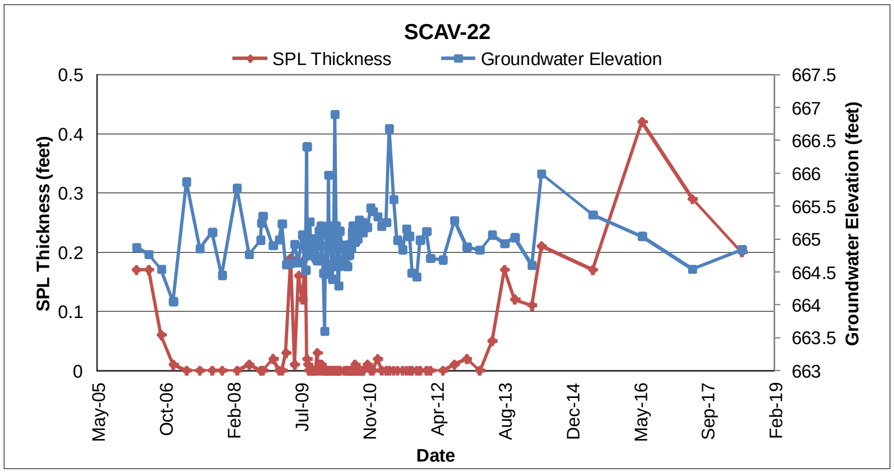
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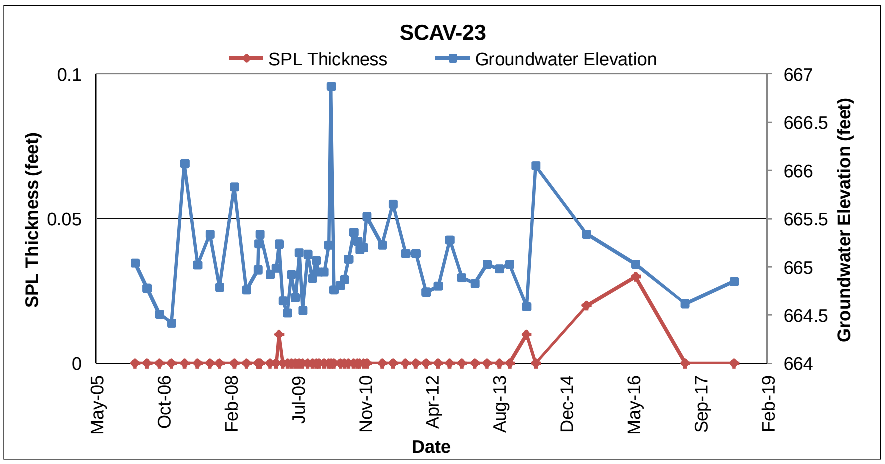
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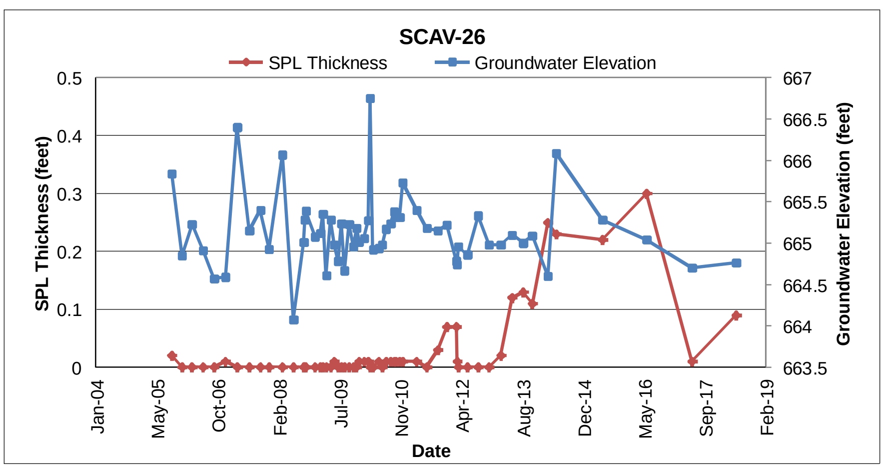
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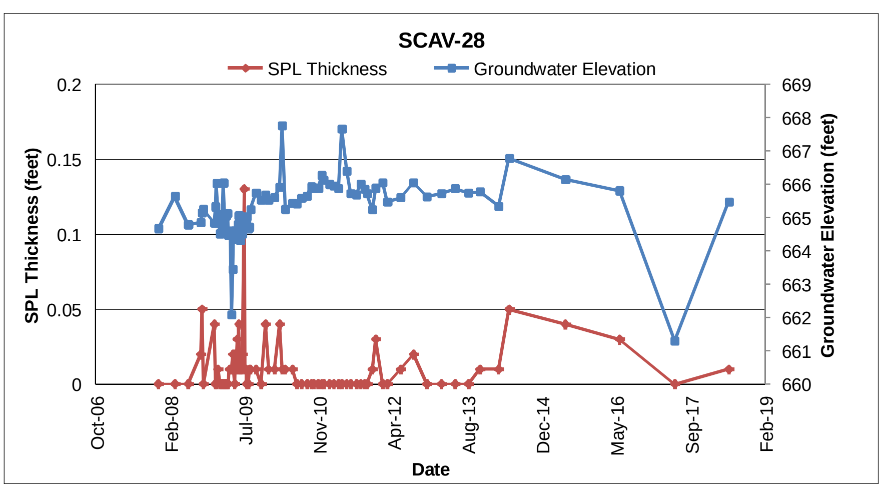
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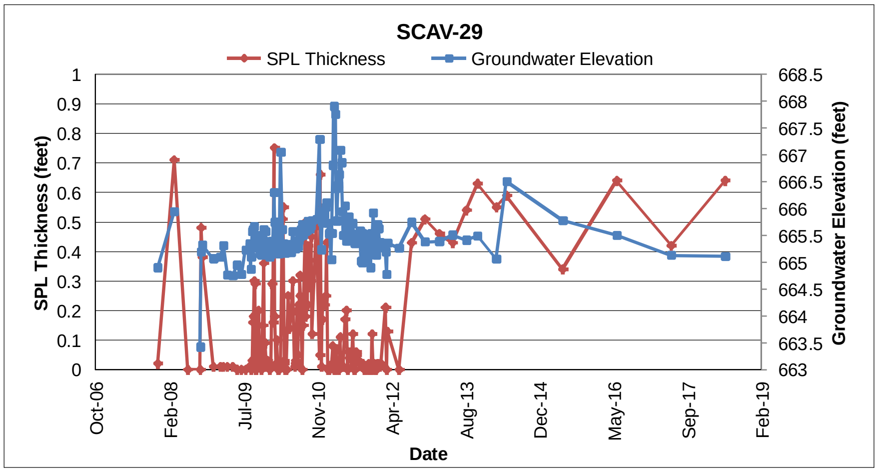
Sep-17
Feb-19



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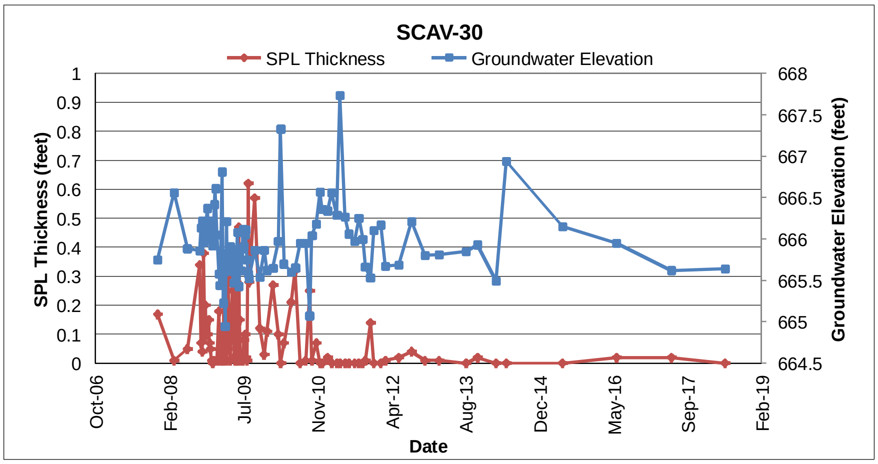

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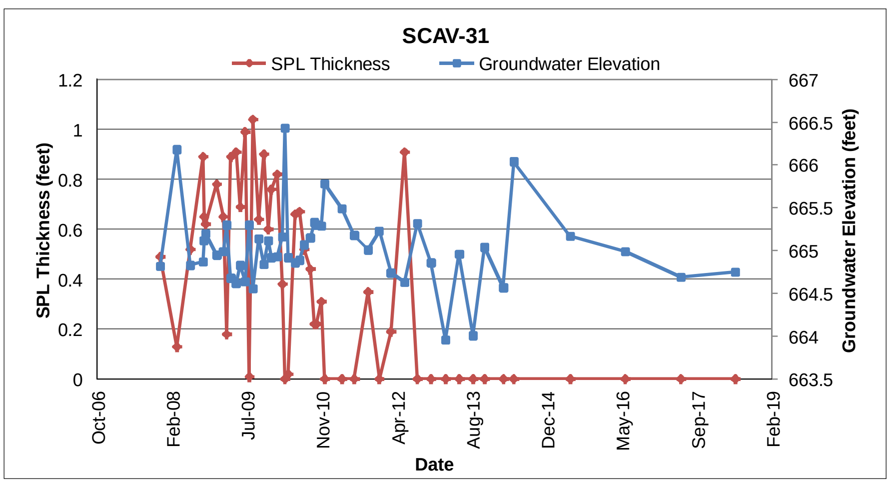

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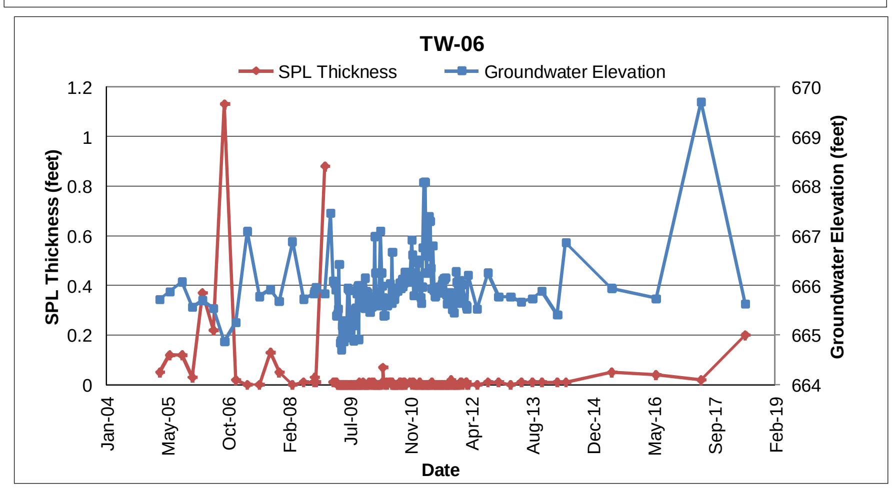
Feb-19



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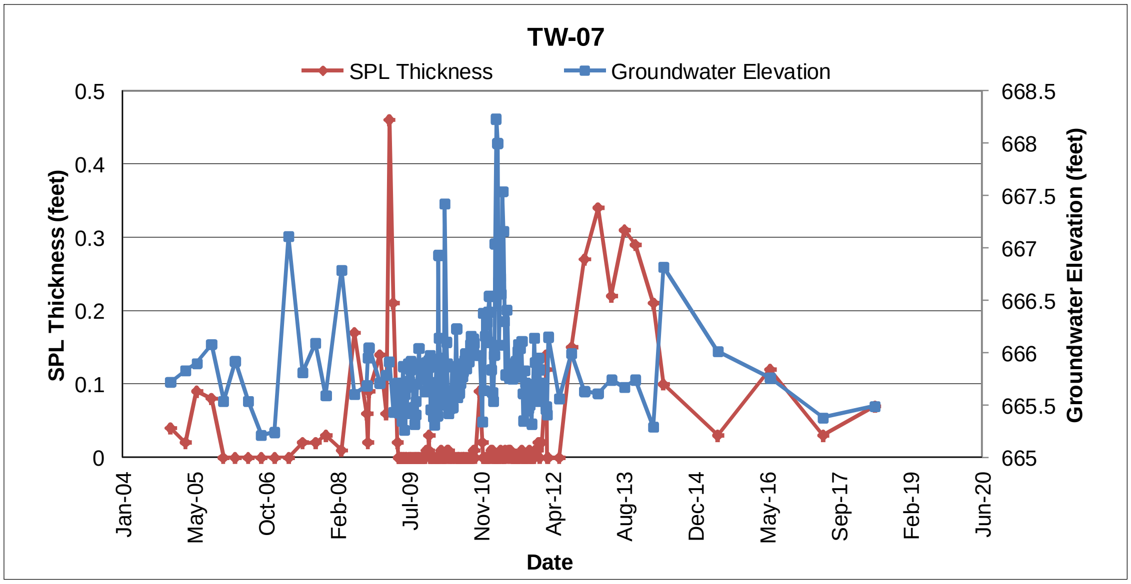

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Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date

Appendix G

Groundwater Fate and Transport Model Simulations of Dissolved COCs

AECOM
300 Lakeside Drive
Suite 400
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www.aecom.com

Memorandum

To	Greg Burgdorf, Senior Project Manager (AECOM, Germantown, MD)
Subject	Summary of BIOSCREEN Model Results for Former Quaker State/ Ergon Refinery Site
From	Jim Zhang, Principal Groundwater Modeler (AECOM, Oakland, CA)
Date	May 10, 2019 (final)

Introduction

Fate and transport modeling of site groundwater using the BIOSCREEN model was conducted to predict the presence of site-related constituents of concern (COCs) in site groundwater and to assess the credibility of biodegradation process of the COCs as support for the selection of a groundwater corrective measure alternative for the Former Quaker State/Ergon refinery, here referred as the Site. The Site occupies approximately 70 acres along the southern bank of the Ohio River, approximately 1.5 miles southwest of the town of Newell, WV. The active Refinery is bordered to the north and northwest by the Ohio River and to the south by State Route 2 and railroad tracks.

The BIOSCREEN modeling study evaluates the natural attenuation processes and movement of two main dissolved COCs at the Site: benzene and toluene. These two compounds have an area of dissolved concentrations with a known/suspected source area that allows fate and transport modeling. In addition, benzene and toluene exist at concentrations greater than their MCLs in certain areas of site groundwater. The objective of the modeling was to predict the extent and concentration of the benzene and toluene in site groundwater in a source area over time and the extent of their plumes, considering the combined effects of advection, dispersion, sorption, and biodegradation. The modeling study attempts to simulate natural processes affecting dissolved petroleum constituents in the subsurface environment, while remaining reasonably conservative and not overestimating constituent mass reduction. Model simulations were conducted based on the general site groundwater conditions, the current dissolved benzene and toluene concentrations, the site-derived biodegradation rates, and the hydrogeological properties of the groundwater system at the Site. The benzene and toluene biodegradations are approximately represented as first-order reactions. The modeling results show the benzene and toluene concentration distributions along the plume center line and the downgradient plume extents at various times. The presence of active biodegradation processes in site groundwater is also demonstrated with the modeling results.

BIOSCREEN Modeling

The BIOSCREEN model is a natural attenuation screening model developed by the Air Force Center for Environmental Excellence (AFCEE) that simulates remediation by natural attenuation (Newell et al. 1996). It is based on an analytical model developed by Domenico (1987), and operates in Microsoft® Excel spreadsheet environment.

The BIOSCREEN model simulates the maximum extent of the dissolved COC plume and the chemical concentrations along the centerline of the plume. It has the ability to simulate the transport processes of advection, dispersion, adsorption/retardation, and sequential first-order degradation. Aerobic decay, as well as anaerobic conditions, which contribute to the degradation of released petroleum chemicals, can also be simulated. While the modeling results provide insight into the COCs migration and biodegradation behavior, the results should be considered estimates only.

The basic input data for BIOSCREEN model are:

- Hydrologic parameters: Seepage velocity, or hydraulic conductivity, hydraulic gradient, and the effective porosity;
- Longitudinal, transverse, and vertical dispersivities;
- Retardation (sorption) factor;
- Solute biodegradation decay rate or half-life;
- Electron acceptor or oxidation product concentrations (i.e., oxygen, nitrate, iron, sulfate, and methane);
- Model area (length and width); and
- Contaminant source zone (thickness, width and concentrations).

The input parameters required for the BIOSCREEN model are based on both field and laboratory data, and typical literature values are used when site-specific data is not available. The model input parameter values are summarized in Table 1. The biodegradation half-life values of benzene and toluene were derived based on benzene and toluene's historical concentration variations over time at multiple monitoring wells at the Site. The decay rate and half-lives used in this modeling was the average value derived from site wells. The wells used and a summary table of biodegradation half-life values are in Attachment A.

For this study, the chemical depletions of benzene and toluene source area were approximated as a first-order decay process, and the half-lives of source depletions were estimated from the benzene and toluene concentration decays in groundwater of the source areas. Specifically, in the benzene source area of MW-31 and the toluene source area of MW-38R, the half-lives of source depletions were estimated as 3.06 and 4.14 years, respectively. Consequently, a source depletion half-life of 5.0 years was conservatively used for both benzene and toluene sources in site groundwater.

The BIOSCREEN model can simulate chemical transport under the following three scenarios:

- First-order Biodegradation: Dissolved phase COC mass is degraded at a rate proportional to the dissolved phase concentration.
- Zero-order Biodegradation: dissolved phase COC is considered without any biodegradation (i.e., no-decay case).
- Instantaneous biodegradation: Degradation rate is much faster than the rate at which electron acceptor and nutrients are replenished within the groundwater system.

For this modeling study, the BIOSCREEN model was conducted <u>under first-order biodegradation scenario</u>, which represents the most realistic site conditions. In addition, the instantaneous degradation scenario was also assessed for the site groundwater; however, results of a test simulation indicated the instantaneous degradation scenario was not applicable to the site. The zero-order biodegradation scenario is included in a sensitivity analysis simulation.

The BIOSCREEN model can be performed either as a constant-source simulation (an infinite source mass is assumed) or a depleting source (a finite source mass is used). For this evaluation, the site was modeled as a depleting source site (assuming a half-life of 5 years). For this analysis, the source material was considered to be dissolved COCs (solute) and the presence of free-phase material (SPL) was not included in the model.

Simulations and Results

The BIOSCREEN model was used to simulate the fate and transport of the dissolved benzene and toluene under natural attenuation conditions in the Site groundwater. For the purpose of the modeling evaluation, the benzene source area is assumed to be located at well MW-31 and toluene source area at MW-38R. Source areas are represented by the highest benzene and toluene concentrations measured at the Site. Thus, for benzene, the source concentration is 0.60 mg/L that was measured at well MW-31 in September 2006, and for toluene, the source concentration is 260 mg/L as measured in MW-38R (June 2017). The distance to the property boundary is approximately 900 feet from well MW-31 and at approximately 1200 feet from well MW-38R. Because of the uncertainties with the benzene and toluene sources, the biodegradation half-life values, and the groundwater velocity at the Site, a sensitivity analysis was conducted that altered these parameters. As summarized in Table 2, three model simulations were conducted for each of benzene and toluene, as follows:

- Baseline: Representative site conditions
- Sensitivity 1: Sensitivity runs for biodegradation rates (with no degradation case)
- Sensitivity 2: Sensitivity runs for groundwater velocity

The baseline simulations were conducted to model dissolved benzene and toluene migration in groundwater under the representative site conditions. For these sensitivity runs, one model input (source, degradation rates, or groundwater velocity) was changed and all other model input parameters were retained.

Baseline Simulations

The baseline simulations were conducted with a depleting source and with a conservatively estimated source depletion half-life of 5 years for both dissolved benzene and toluene sources. Based on historical concentration variations at multiple monitoring wells, the half-life values of biodegradation were set to 1.77 and 2.68 years for benzene and toluene, respectively (Attachment A). The groundwater velocity was set to 18.6 ft/year, based on the shallow zone hydraulic conductivity (34.0 ft/day), the average observed hydraulic gradient (0.0003), and the literature value of effective porosity of 0.20. The model was conducted for periods of 35 and 50 years for benzene (Figure 2-b) and toluene (Figure 3-b), when the maximum concentrations in the source area decline to less than their maximum concentration levels (MCLs) of 5.0 μg/L and 1.0 mg/L, respectively. Baseline simulation results are summarized in Table 3.

Figures 2-a and 2-b (normal-scale and log-scale in concentration, respectively) show the modeled benzene concentration distributions along the plume centerline. As shown in the figures, as benzene migrates downgradient, benzene concentrations decrease quickly over distance from the source (mainly due to biodegradation), and the modeled plume extent with concentration exceeding its MCL of 5.0 μg/L approaches “steady-state” (i.e., plume does not migrate further downgradient) in approximately 15 years. The model results show that the modeled maximum benzene concentration does not reach 5.0 μg/L in 35 years after model simulation, and benzene with concentration exceeding its MCL would extend a maximum distance of approximately 110 feet from the source zone.

The figures also show that the benzene plume with concentration exceeding its MCL starts to shrink towards the source zone (source zone has the highest concentrations) after approximately 28 years. The modeled maximum benzene concentrations decrease over time in the source area and become less than 5.0 μg/L in 35 years after start of model simulation. Of note is the modeled benzene concentration of 0.60 mg/L represents well MW-31 in September 2006, and thus, the model is at 12 years in 2018. Also, the degradation of the benzene to less than its MCL is an additional 23 years from 2018 with the presumed input parameters. The actual benzene concentration detected in well MW-31 in 2018 of 28.5 ug/L is less than the predicted benzene concentration of approximately 100 ug/L per the simulation. This favorable comparison provides credibility to the results of the baseline benzene simulation.

Figures 3-a and 3-b (normal-scale and log-scale in concentration, respectively) show the modeled toluene concentration distributions along the plume centerline. As shown in the figures, as toluene migrates downgradient, toluene concentrations decrease quickly over distance from the source, but at a rate slower than that of benzene concentration decreasing, due to toluene’s higher biodegradation half-life (slower decay rate). The modeled toluene plume extent with concentration exceeding its MCL of 1.0 mg/L approaches “steady-state” in approximately 20 years, which is longer than that of benzene because toluene has a higher sorption coefficient (i.e., higher retardation) and a slower decay rates. The model results also show that the modeled maximum toluene concentration does not reach 1.0 mg/L in 50 years, and toluene plume with concentration exceeding its MCL would also extend a maximum distance of approximately 110 feet from the source zone. This result of the simulation is similar to the extent of a known toluene release in the MEK Dewaxing Area. Dissolved toluene concentrations were not detected greater than its MCL at a distance of greater than 150 feet from areas of known free-phase toluene.

As shown on the figures, the toluene plume with concentration exceeding its MCL starts to shrink after approximately 40 years when the source zone concentration declines to its MCL, and the modeled maximum toluene concentrations decrease over time and becomes less than its MCL of 1.0 m/L in 50 years.

In summary, the baseline simulation results show that dissolved benzene and toluene at concentrations exceeding their MCLs would approach "steady-state" in approximately 15 and 20 years after start of simulation, respectively. The "steady-state" plumes with benzene or toluene concentrations exceeding the MCLs of 5.0 μg/L and 1.0 mg/L are predicted to extend only approximately 110 feet downgradient of their source area. The simulation results also show that the maximum benzene and toluene plume concentrations are predicted to decrease below their MCLs in approximately 35 years and 50 years after start of simulations, respectively. Thus, under existing site conditions, such small downgradient extents of the steady-state benzene and toluene plumes indicate that the plumes will not reach the downgradient property line. A buffer area of 800 to greater than 1000 feet would exist for the respective benzene and toluene plumes to continue to degrade prior to reaching the property line, if they were to continue to move in that direction.

These two model simulations demonstrate that dissolved benzene and toluene plumes from the identified source areas would not extend downgradient to the property boundary, even under the worst case scenario. A comparison of the different simulations with actual site data indicates that active biodegradation is occurring in site groundwater to reduce the COC concentrations. For both benzene and toluene, extensive downgradient plumes from known source areas have not been detected in site groundwater. This condition and finding supports the potential use of a monitored natural attenuation (MNA) or no action alternative at the Site.

Sensitivity 1: Model Simulations for Biodegradation Rates

For this sensitivity analysis, the modeled simulations were the same as the baseline simulations, but the benzene and toluene biodegradation half-life values were changed. Except for biodegradation half-life values, no other parameters were changed.

Sensitivity 1A: Biodegradation half-life values were doubled

For these sensitivity runs, the biodegradation half-life value was doubled (i.e., biodegradation rate was decreased by half) for both benzene and toluene. Specifically, the half-life was increased from 1.77 and 2.68 years to 3.54 and 5.36 years for benzene and toluene, respectively. Other than the biodegradation rates, all other model input parameters were retained in these sensitivity runs.

The model was run for periods of 40 and 77 years for benzene and toluene when the modeled maximum benzene and toluene concentrations reach the MCLs of benzene and toluene (i.e., 5.0 μg/L and 1.0 mg/L), respectively. Results of sensitivity simulations for biodegradation rates are summarized in Table 3.

Figures 4-a and 4-b (normal-scale and log-scale in concentration, respectively) show the modeled benzene concentration distributions along the plume centerline with the increased biodegradation half-life value of 3.54 years. Similar to the baseline scenario, the figures show that benzene concentrations decrease quickly with distance from the source, but the decreasing rate is slower. Due to the increased half-life value (i.e., decreased decay rate), the modeled benzene concentrations are generally higher than those modeled by baseline simulation. The modeled benzene plume exceeding 5.0 μg/L approaches steady-state conditions in 25 years and extends approximately 165 feet downgradient from the source area (approximately 55 feet greater than the base-line simulation).

Figures 5-a and 5-b show the modeled toluene concentration distributions along the plume centerline with the increased half-life value of 5.36 years. Similar to the baseline scenario, the figures show that toluene concentrations decrease quickly with distance from the source, but the decreasing rate becomes slower. Due to the increased half-life value (i.e., decreased decay rate), the modeled toluene concentrations are generally higher than those modeled by baseline simulation. The modeled benzene plume exceeding 1.0 mg/L approaches steady-state conditions in 40 years and extends approximately 170 feet downgradient from the source area (approximately 60 feet greater than the base-line simulation).

Sensitivity 1B: Biodegradation was not modeled

The model was also performed for both benzene and toluene using a no-degradation scenario for a worst case comparison to the first order degradation simulations. A comparison of the no-degradation simulation results to the first-order degradation results and to the actual groundwater chemical data will provide credibility of biodegradation of the COCs in site groundwater and support the possible MNSA remedy.

Other than no degradation, all transport input parameters of baseline simulations are retained. Due to the much slower concentration decrease overtime in the absence of degradation, model area and simulation time were extended. Specifically, the modeled area is extended from 200 ft to 1,000 feet downgradient of the source area for both benzene and toluene, and the simulation time is increased to 200 and 400 years for benzene and toluene, respectively.

Figure 6 shows the modeled benzene concentration distributions along the plume centerline under the no-degradation scenario. As shown in the figures, benzene concentrations decrease much slower than the first-order degradation scenario, since hydrodynamic dispersion is the only transport process that will cause a benzene concentration reduction as it migrates downgradient in groundwater. The results show that the concentration distribution does not approach steady-state in 200 years. At 20 and 50 years, dissolved benzene at a concentration exceeding its MCL of 5.0 μg/L is predicted to extend approximately 220 and 420 feet downgradient of the source zone, with modeled maximum concentration of approximately 200 and 180 μg/L, occurring at 100 and 200 ft downgradient of the source zone, respectively. At the end of model simulation (200 years), dissolved benzene at a concentration exceeding its MCL of 5.0 μg/L is predicted to extend over 1,000 feet downgradient of the source zone, with peak concentration of approximately 60 μg/L occurring at 825 feet downgradient of the source area.

Figure 7 shows the modeled toluene concentration distributions along the plume centerline under the no-degradation scenario. Similar to benzene, toluene concentrations decrease much slower than the first-order degradation scenario, also because hydrodynamic dispersion is the only transport process that causes the decrease of toluene as it migrates downgradient in groundwater. As shown in the figure, the toluene concentration distribution does not approach steady-state in 400 years. At 50 and 100 years, dissolved toluene at a concentration exceeding its MCL of 1.0 mg/L is predicted to extend approximately 300 and 500 feet downgradient of the source zone, with modeled maximum concentration of approximately 72 and 40.0 mg/L, occurring at 100 and 240 ft downgradient of the source zone, respectively. At the end of model simulation (400 years), dissolved toluene at a concentration exceeding its MCL of 1.0 mg/L is predicted to extend over 1,000 feet downgradient of the source zone, with peak concentration of 35 mg/L occurring approximately 800 ft downgradient of the source zone. In summary, doubling the biodegradation half-life values resulted in longer "steady-state" benzene and toluene plumes (approximately 55 and 60 feet longer for benzene and toluene, respectively). It results in longer times for the benzene and toluene plumes to reach their "steady-state" plume conditions (10 and 20 years longer for benzene and toluene extents, respectively), and longer times for the maximum benzene and toluene concentrations to decline below their MCLs (5 and 27 years longer for benzene and toluene maximum concentrations, respectively).

For no degradation case, benzene and toluene concentrations decrease much slower because hydrodynamic dispersion is the only transport process that causes the decrease of benzene and toluene. The modeled concentration distributions do not approach steady-state during the entire simulation times of 200 and 400 years for benzene and toluene, respectively, and the model maximum concentrations do not reach the MCLs during the entire simulation times for both benzene and toluene. These no degradation model results support that biodegradation is occurring for both benzene and toluene in site groundwater.

<u>Sensitivity 2: Model Simulations for Groundwater Velocity</u>

For these sensitivity simulations, the groundwater velocity was doubled from 18.6 ft/year to 37.2 ft/year. Other than the groundwater velocity, all other model input parameters were retained in these sensitivity runs. The model was run for periods of 35 and 40 years for benzene and toluene when the modeled maximum plume concentrations decline below their MCLs, respectively. Results of sensitivity simulations for groundwater velocity are summarized in Table 3.

Figures 8-a and 8-b (normal-scale and log-scale in concentration, respectively) show the modeled benzene concentration distributions along the plume centerline with the increased groundwater velocity. Similar to baseline scenario, the figures show that benzene concentrations decrease quickly with distance from the source, but the rate of concentration reduction is slower due to the increased groundwater velocity, resulting in a larger benzene plume area relative to the baseline simulation. Model results show that the 5.0 μg/L benzene plume reaches steady-state conditions in 15 years and extends a distance of 165 feet from the source zone, which is 55 feet longer than in the baseline simulation.

Figure 8-b also shows that the 5.0 μg/l benzene plume starts to shrink towards the source zone (i.e., source zone has the highest concentrations) after approximately 22 years, and the modeled maximum benzene concentrations (occurring in the source area) decrease below MCL of 5.0 μg/L in 35 years.

Figures 9-a and 9-b show the modeled toluene concentration distributions along the plume centerline with the increased groundwater velocity. The figures show that the modeled toluene plume migrates downgradient quickly, resulting in a larger toluene plume area relative to the baseline simulation. Model results show that the 1.0 mg/L toluene plume reaches steady-state conditions in 25 years and extends a distance of 170 feet from the source zone, which is 60 feet longer than in the baseline simulation. Figure 9-b also shows that the modeled toluene concentrations decrease quickly over time, and the 1.0 mg/L toluene plume disappears in approximately 40 years.

In summary, increasing the groundwater velocity also resulted in increased plume extents (approximately 55 and 60 feet longer for benzene and toluene, respectively) as compared to the baseline simulations and slightly longer time for toluene to reach its “steady-state” plume extent. However, it results in slightly shorter time for the maximum toluene concentrations to decline below its MCLs.

Conclusion

The fate and transport modeling conducted using BIOSCREEN shows that using reasonably conservative site derived natural attenuation parameters predicts relatively small dissolved COC plumes downgradient of benzene and toluene source areas and supports that the dissolved plumes would not migrate to the property line at levels exceeding an MCL. Model simulations were performed with depleting sources with a conservatively estimated half-life of 5 years and site-derived decay rates indicate that benzene or toluene groundwater concentrations above their MCL would only extend 110 feet downgradient from source areas, respectively. These simulations provide a reasonable agreement with actual site data that indicates active biodegradation in site groundwater is occurring. In addition, a distance of approximately 800 feet is predicted to exist between the downgradient edge of the dissolved COCs at their MCLs and the property boundary at the river, as determined by the baseline simulations.

A sensitivity analysis was conducted by altering the main parameters affected fate and transport of the dissolved COCs, biodegradation rates, and groundwater velocity. Even when the biodegradation half-life value was doubled and doubling the groundwater velocity was doubled in the baseline simulation for both COCs, the downgradient extent of benzene and toluene concentrations above its MCLs only increased by 60 feet (less than 200 feet downgradient from source areas). Considering the property line is 900 feet or more downgradient from the potential source areas, a significant buffer area (over 600 feet long) exists for continued natural attenuation to degrade both constituents.

Results of this fate and transport analysis indicate a MNA or a no action alternative should be protective of downgradient receptors as the dissolved petroleum COCs in site groundwater will not reach the property boundary as the biodegradation process reduces the COC distribution and concentrations.

References

Domenico, P.A. 1987. An Analytical Model for Multidimensional Transport of a Decaying Contaminant Species. Journal of Hydrology, 91 (1987) 49-58.

Newell, C.J., McCleod, R.K., and Gonzales, J., 1996. BIOSCREEN Natural Attenuation Decision Support System, EPA/600/R-96/087. August. https://www.epa.gov/water-research/bioscreen-natural-attenuation-decision-support-system.

Attachments

Cited Tables and Figures

Table 1: Summary of BIOSCREEN Model Input Parameters

Model Parameter	Unit	Value	Note
Hydraulic Properties			
Hydraulic Conductivity	ft/day	34.0	Site specific, based on average of shallow zone K values from aquifer test
Hydraulic Gradient	ft/ft	0.0003	Site specific, based on groundwater surface elevations at the site
Effective Porosity	Dimensionless	0.20	Literature value
Groundwater Velocity	ft/year	18.6	Calculated
Dispersion			
Longitudinal Dispersivity	ft	30.0	Approximately 10% of the plume dimension in transport direction
Transverse Dispersivity	ft	3.0	10% of longitudinal dispersivity
Vertical Dispersivity	ft	0.3	10% of longitudinal dispersivity
Adsorption			
Soil Bulk Density	kg/L	1.65	Typical literature value
Fraction of Organic Carbon	Dimensionless	0.0066	Site specific value (from VLEACH model for the Site)
Sorption Coefficient			
Benzene	L/kg	66.07	Benzene chemical property
Toluene	L/kg	140.0	Toluene chemical property
Biodegradation			
1st-Order Decay Half Life			
Benzene	Year	1.77	Site specific (based on historical concentrations at various monitoring wells)
Toluene	Year	2.68	Site specific (based on historical concentrations at various monitoring wells)
General Model Parameters			
Modeled Area Length	ft	400	Site specific (based on current Benzene and Toluene concentrations in multiple monitoring wells)
Modeled Area Width	ft	400	
Simulation Time	Year	50	Model results approach steady-state in less than 50 years except for no-decay cases
Source Data			
Source Thickness (Saturated Zone)	ft	15	Shallow water bearing zone thickness
Source Zone Solute Concentrations			
Benzene	mg/L	0.6	Site specific, based on highest concentration in MW-31 in 2006
Toluene	mg/L	262	Site specific, based on "current" (June 2017) concentration in MW-38R
Source Half Life	Year	5	Conservative estimation (based on historical concentration variations in source area)

Table 2: Summary of Model Simulation Cases

Case	Degradation Half Life (years)		Groundwater Velocity (ft/yr)	Note
	Benzene	Toluene		
Baseline	1.77	2.68	18.6	Most realistic model inputs are used
Sensitivity 1A	3.54	5.36	18.6	Biodegradation half life is doubled
Sensitivity 1B	Infinite	Infinite	18.6	No biodegradation is assumed
Sensitivity 2	1.77	2.68	37.2	Groundwater velocity is doubled

Notes:

1. Scenario 1 is the baselline simulation on which the sensitivity runs are based
2. Highlighted in yellow reflects changes from baseline simulation

Table 3: Summary of Model Results

Case	Time (years) to Drop below MCLs [1]		Extent (ft, from source) of "Steady-state" Plume [2]		Time (years) to Reach "Steady-state" Plume Extent	
	Benzene	**Toluene**	**Benzene**	**Toluene**	**Benzene**	**Toluene**
Baseline	35	50	110	110	15	20
Sensitivity 1A	40	77	165	170	25	40
Sensitivity 1B	> 300	> 500	>1,000	>1,000	> 300	> 500
Sensitivity 2	35	40	165	170	15	25

Note:

1: MCLs (maximum concentration levels) of Benzene and Toluene are 5.0 µg/L and 1.0 mg/L

2: Plume refers to area with concentration exceeding the MCLs.

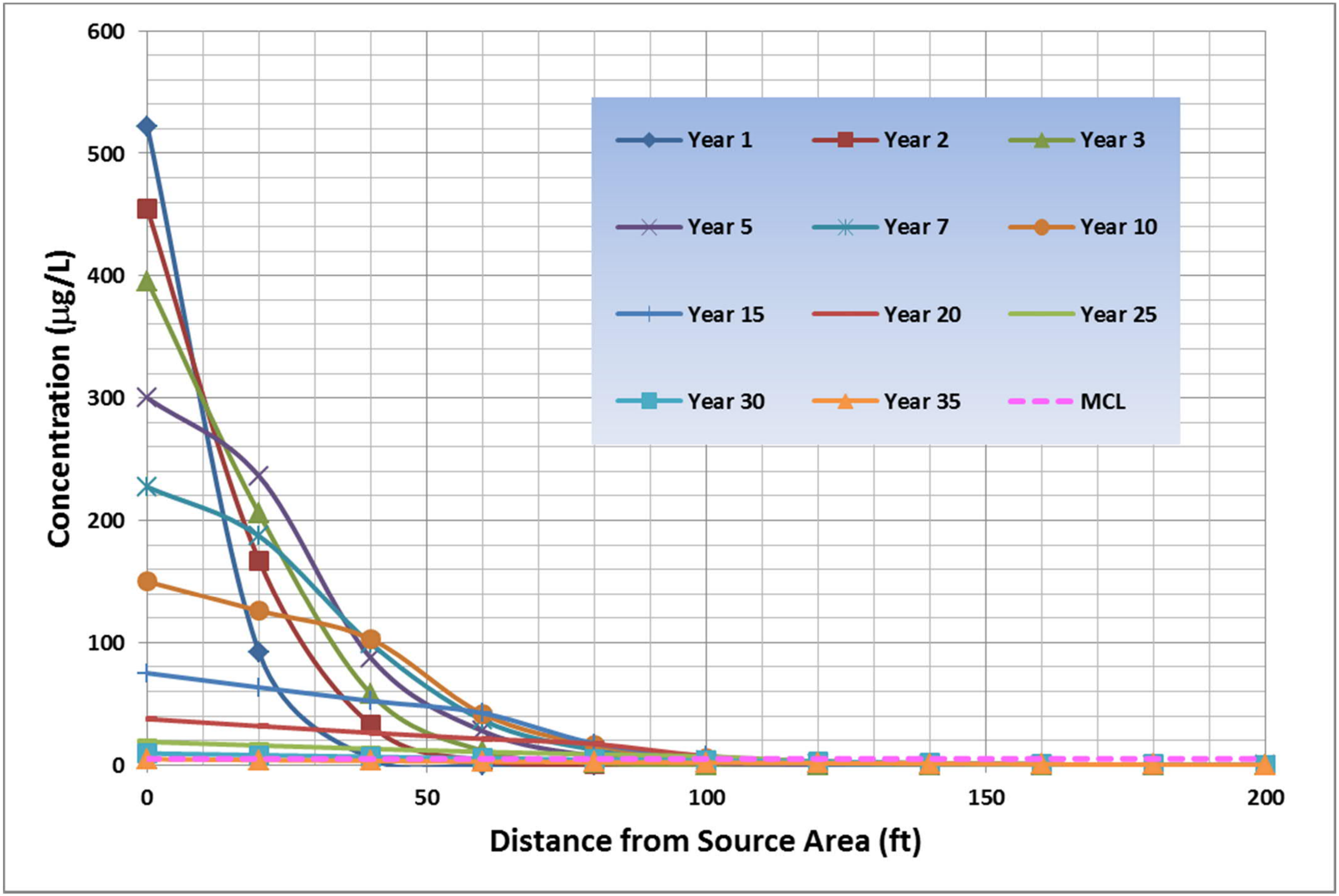

Figure 2-a: Modeled Benzene Concentrations along Plume Centerline: Baseline Simulation (Normal-scale)

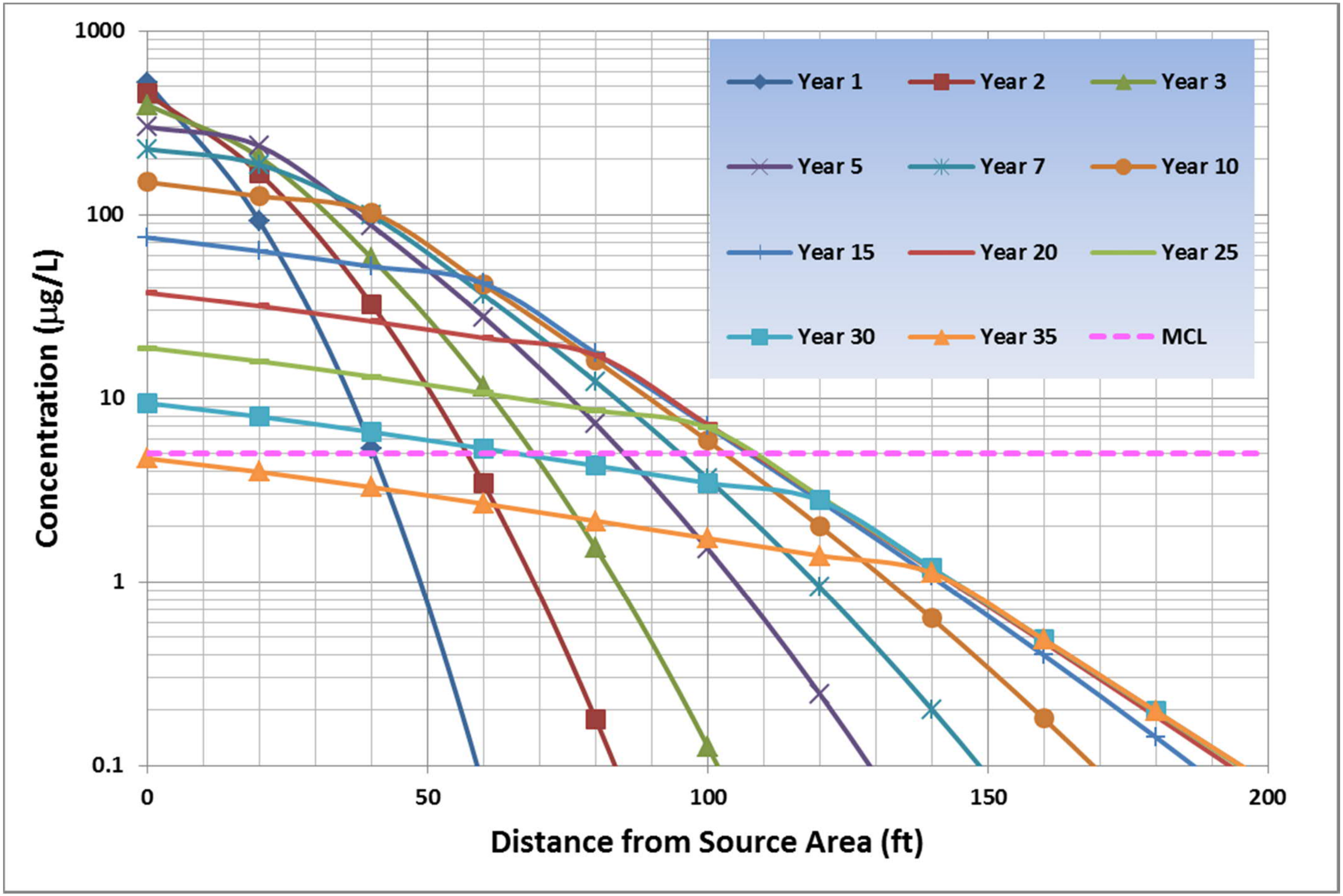

Figure 2-b: Modeled Benzene Concentrations along Plume Centerline: Baseline Simulation (Log-scale)

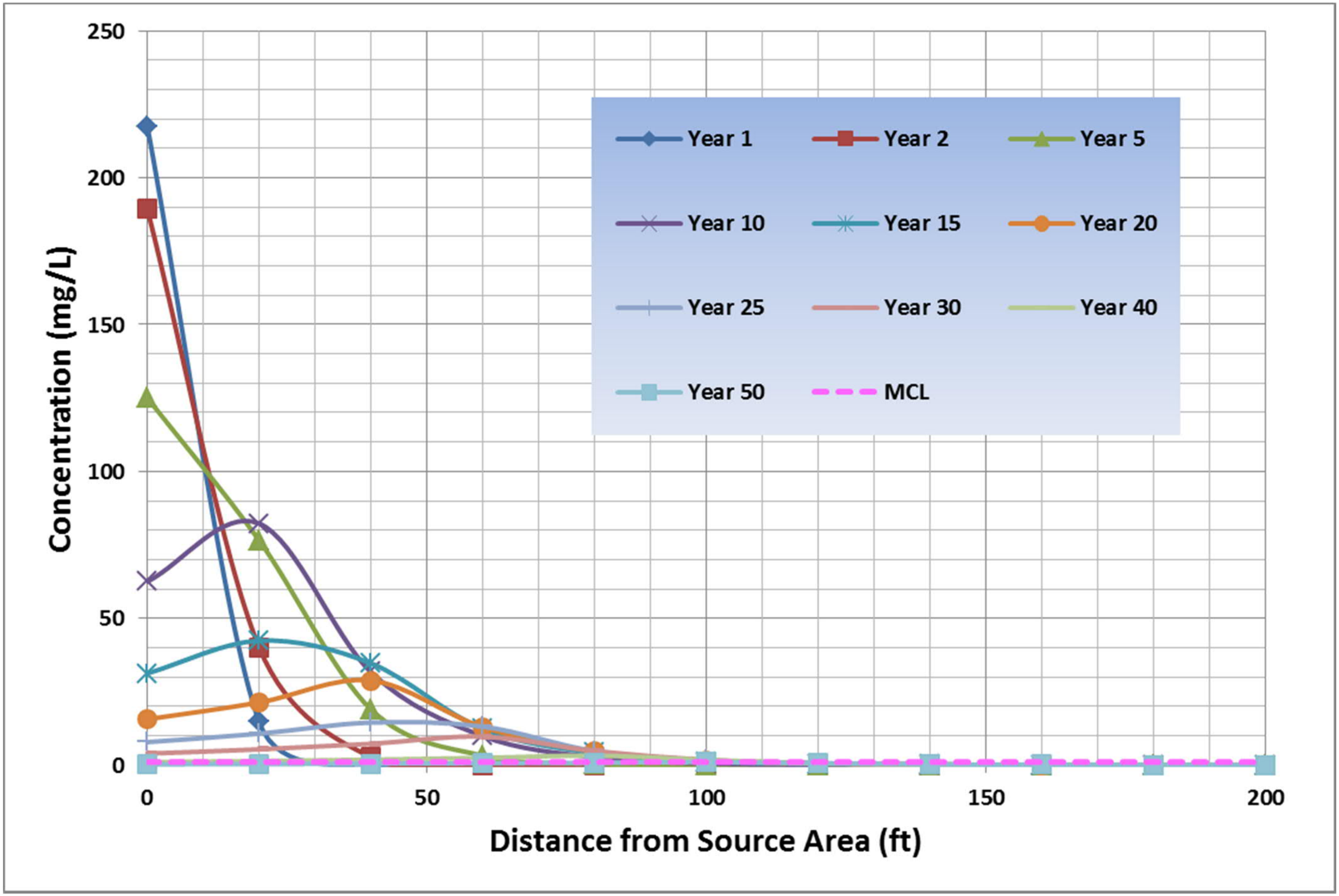

Figure 3-a: Modeled Toluene Concentrations along Plume Centerline: Baseline Simulation (Normal-scale)

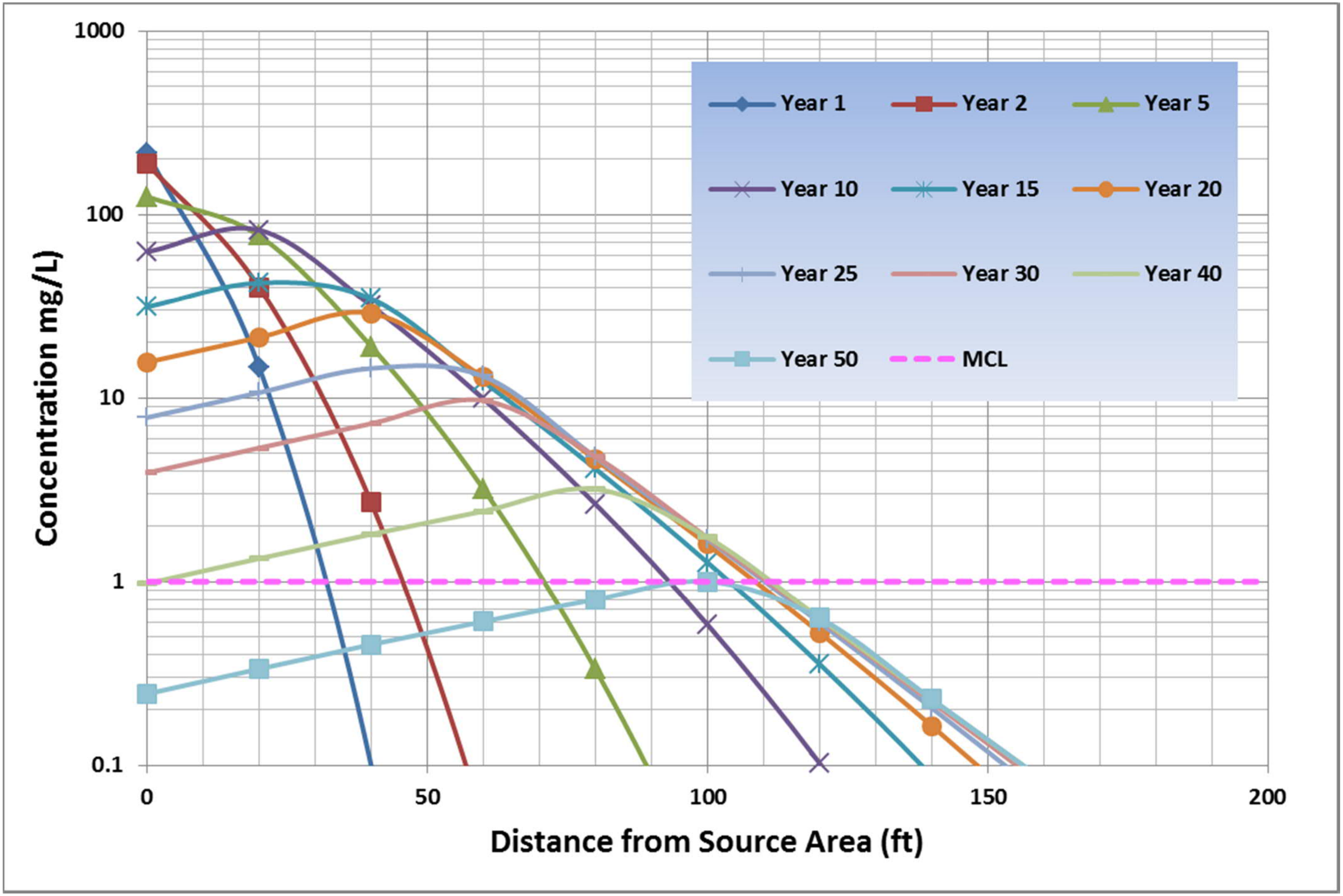

Figure 3-b: Modeled Toluene Concentrations along Plume Centerline: Baseline Simulation (Log-scale)

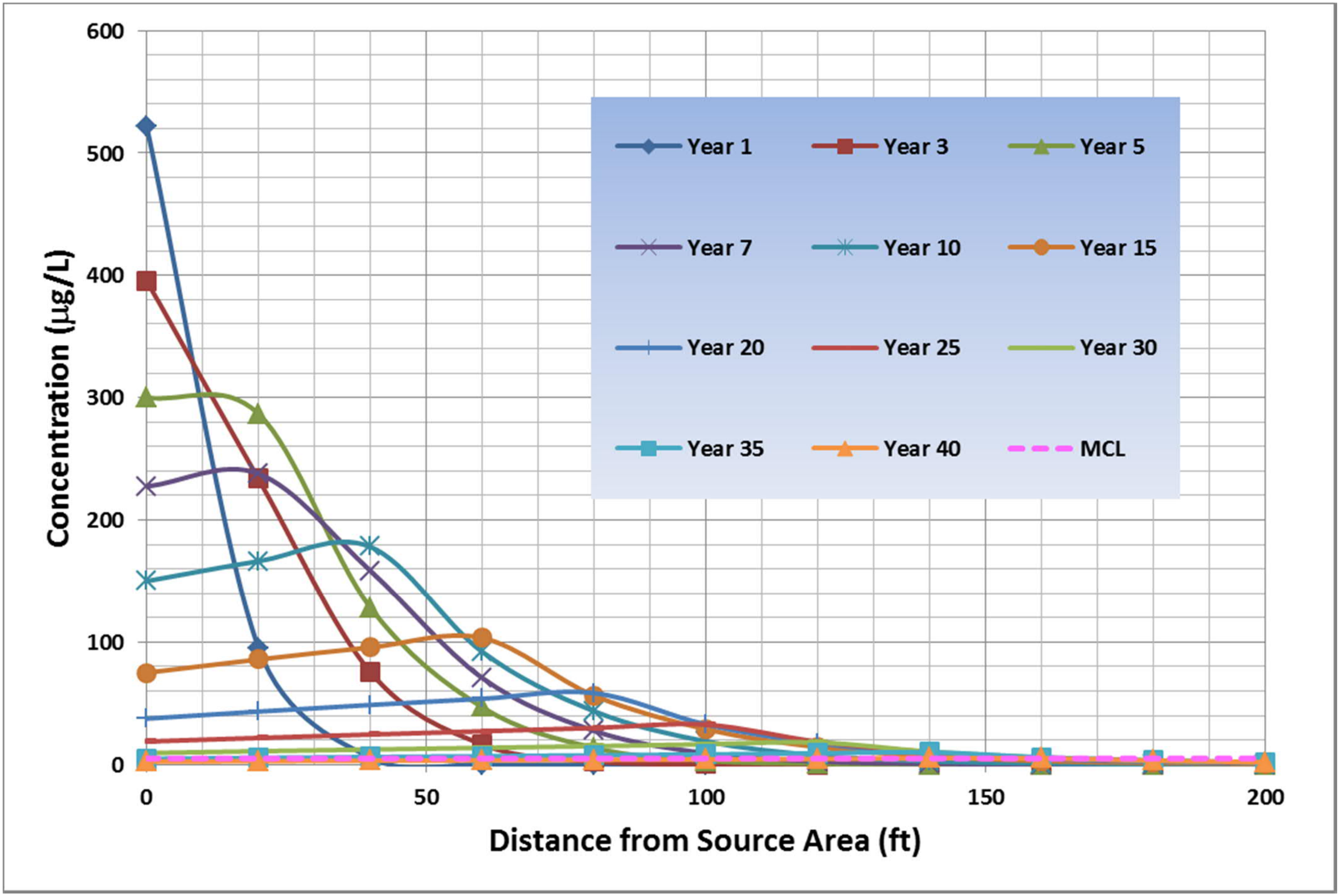

Figure 4-a: Modeled Benzene Concentrations along Plume Centerline: Sensitivity 1A (biodegradation half-life is doubled) (Normal-scale)

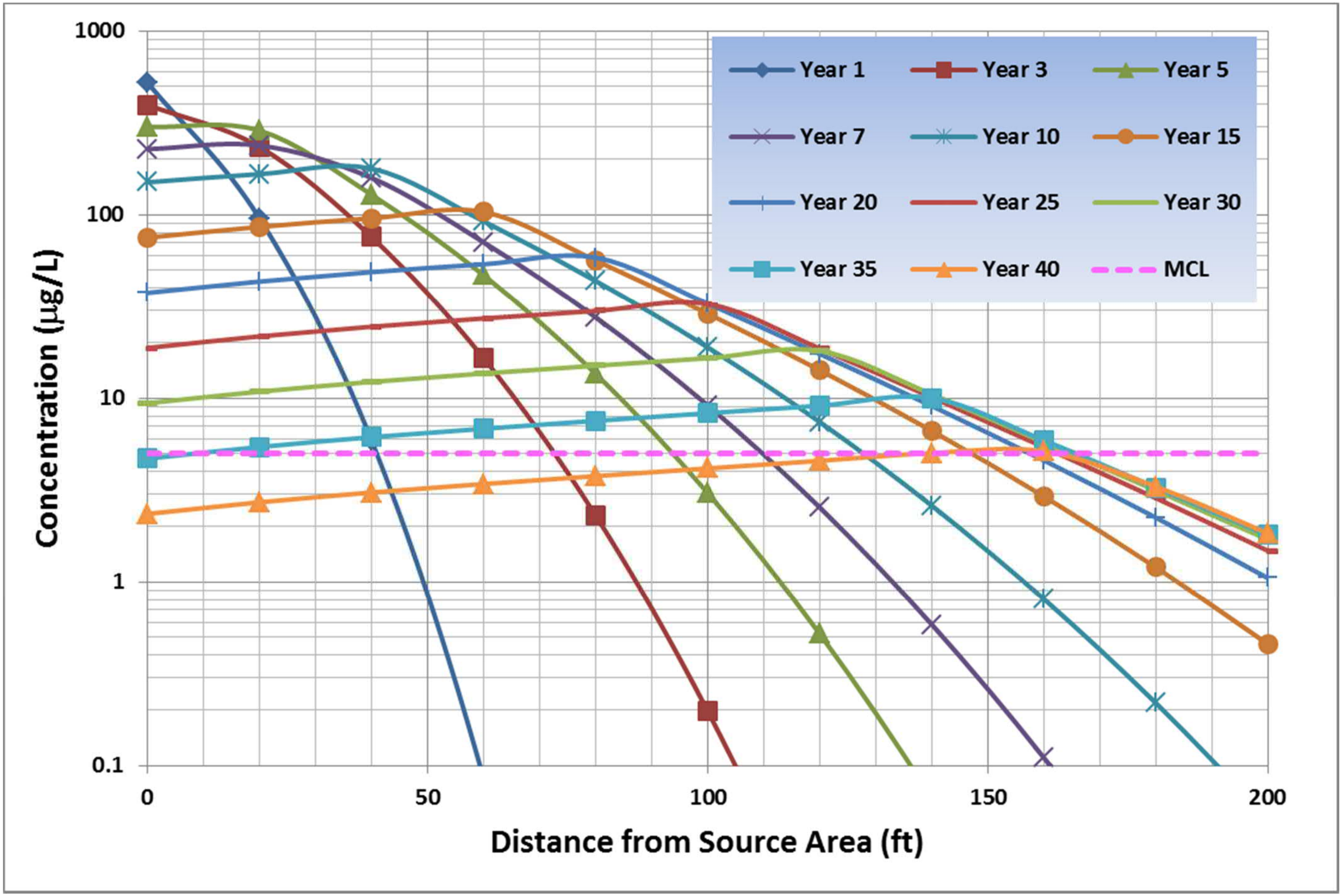

Figure 4-b: Modeled Benzene Concentrations along Plume Centerline: Sensitivity 1A (biodegradation half-life is doubled) (Log-scale)

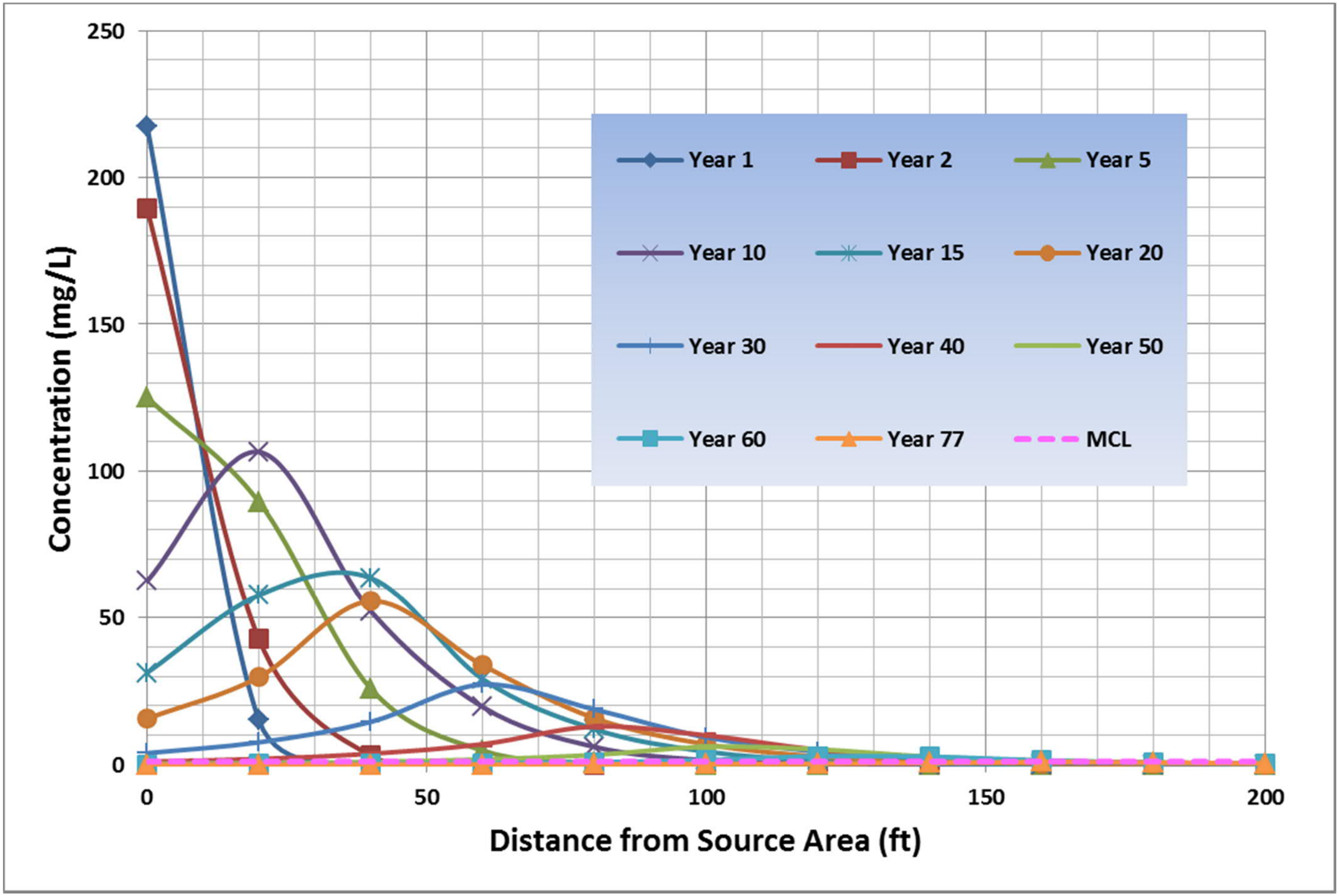

Figure 5-a: Modeled Toluene Concentrations along Plume Centerline: Sensitivity 1A (biodegradation half-life is doubled) (Normal-scale)

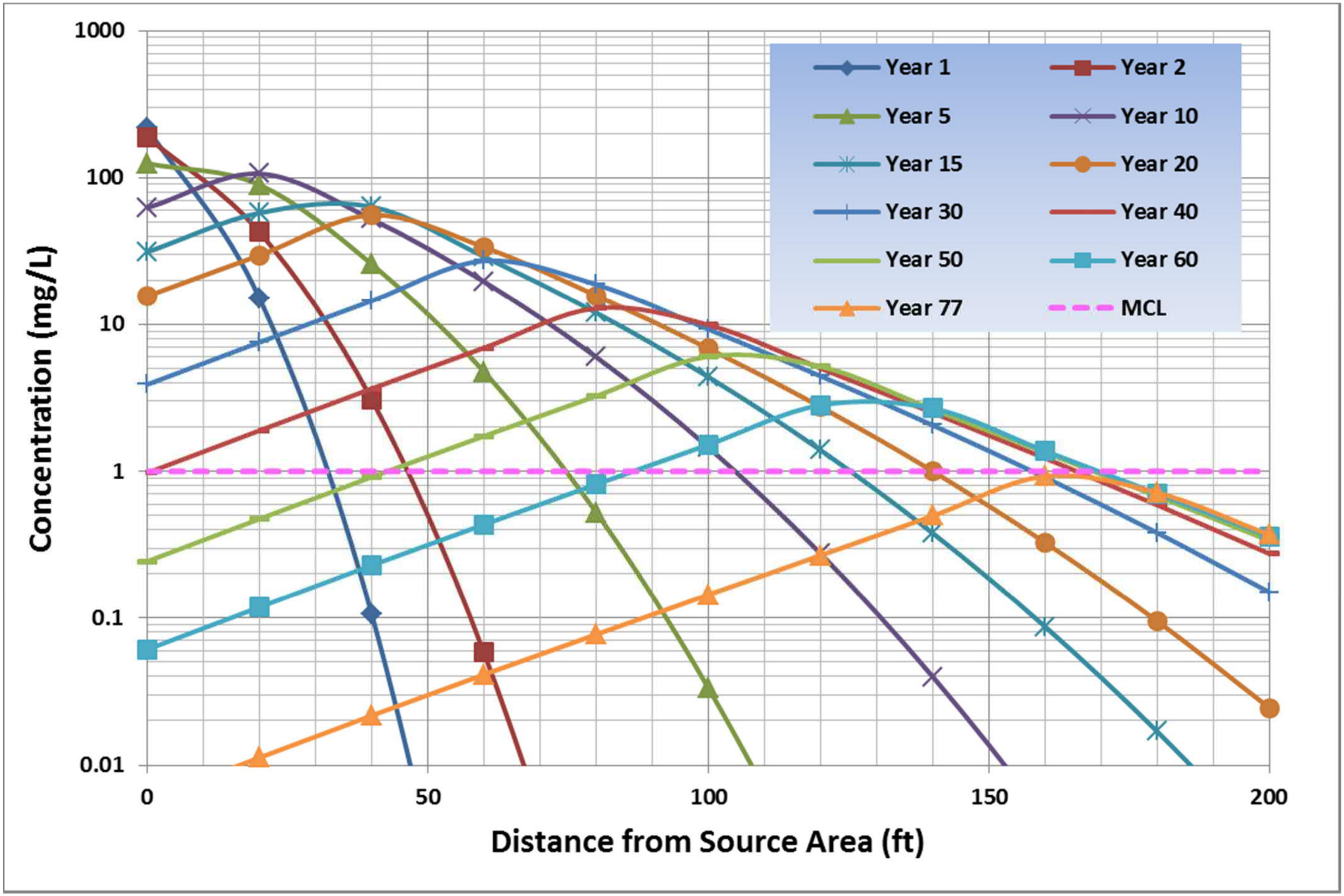

Figure 5-b: Modeled Toluene Concentrations along Plume Centerline: Sensitivity 1A (biodegradation half-life is doubled) (Log-scale)

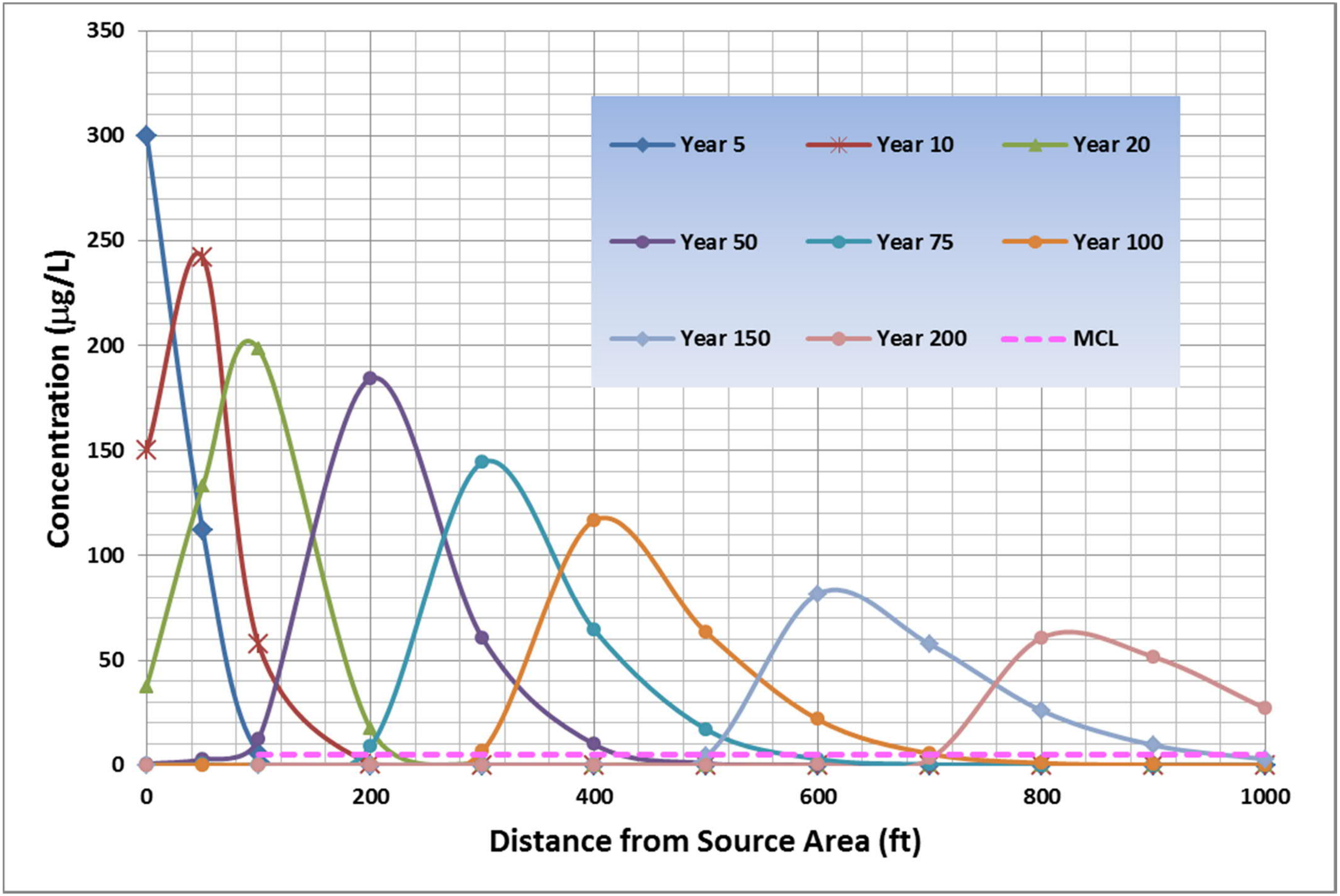

Figure 6: Modeled Benzene Concentrations along Plume Centerline: Sensitivity 1B (No biodegradation is modeled)

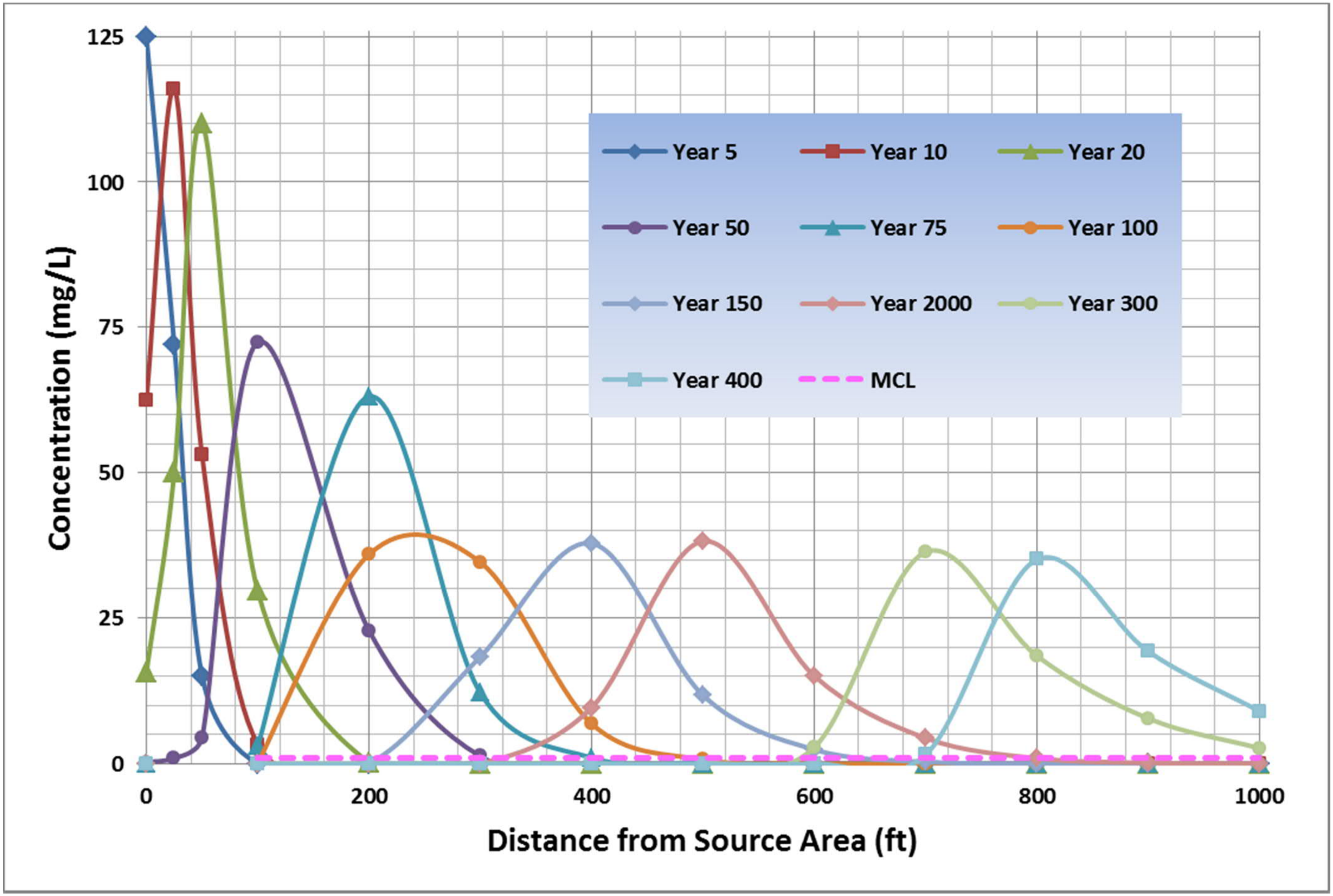

Figure 7: Modeled Toluene Concentrations along Plume Centerline: Sensitivity 1B (No biodegradation is modeled)

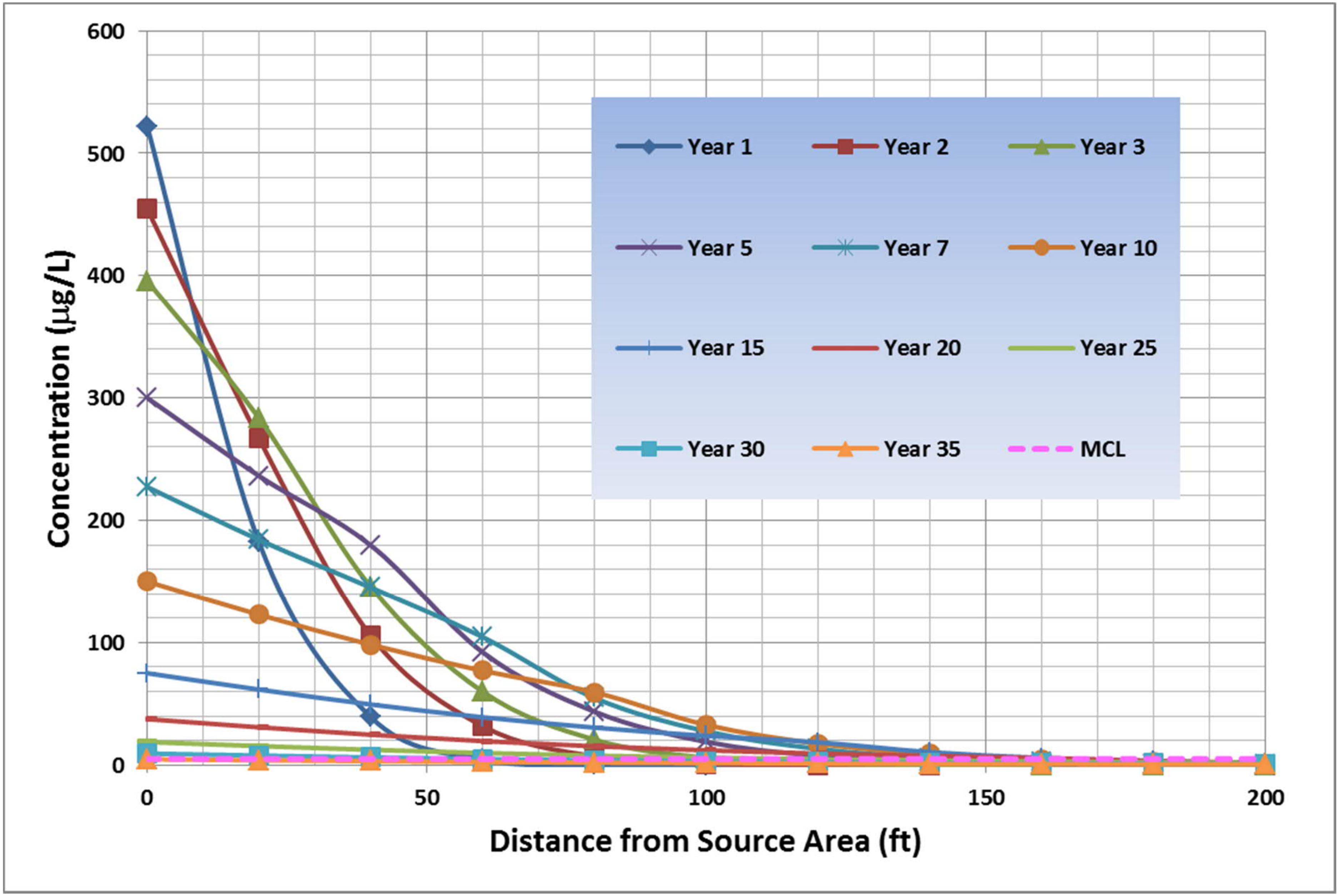

Figure 8-a: Modeled Benzene Concentrations along Plume Centerline: Sensitivity 2 (groundwater velocity is doubled) (Normal-scale)

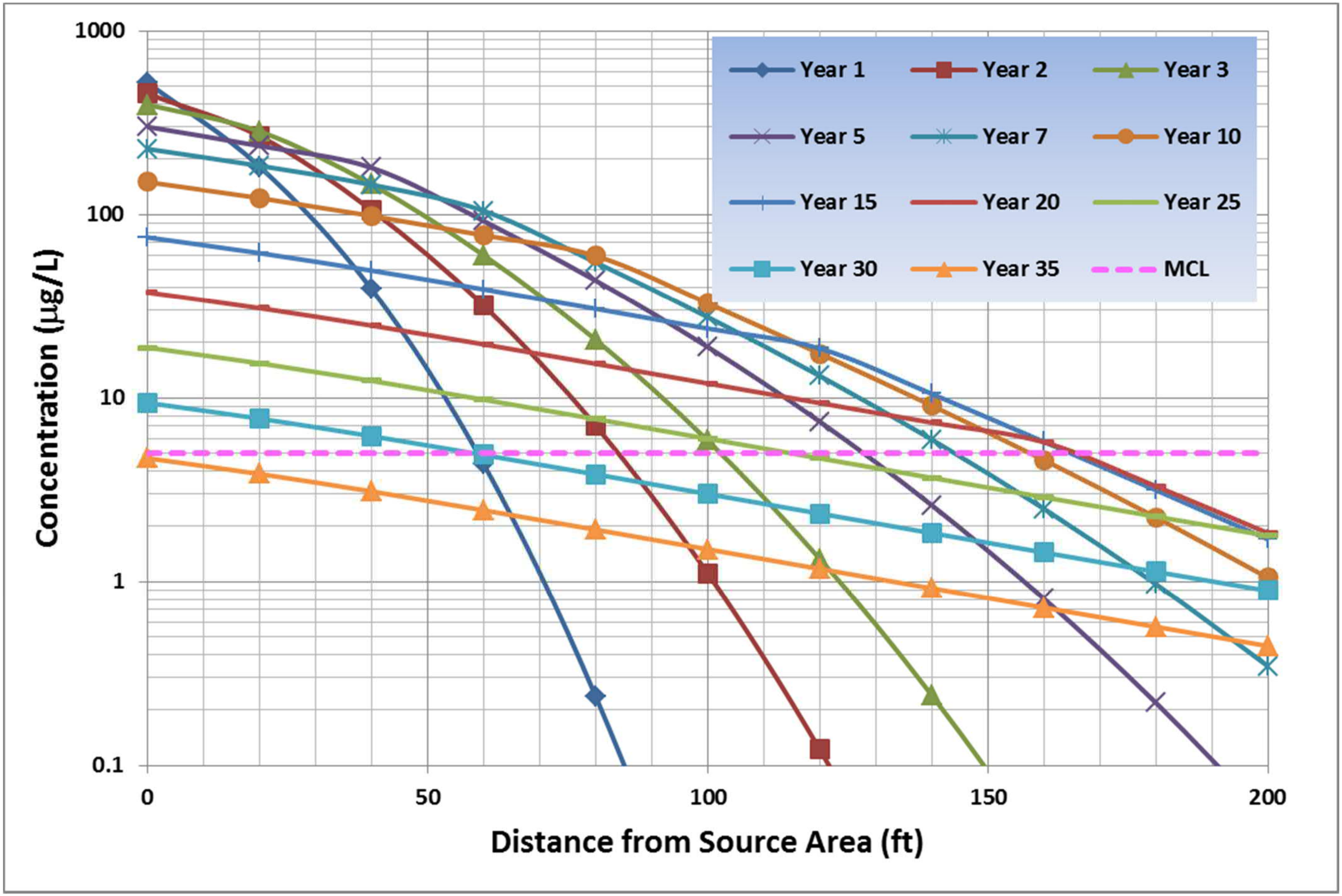

Figure 8-b: Modeled Benzene Concentrations along Plume Centerline: Sensitivity 2 (groundwater velocity is doubled) (Log-scale)

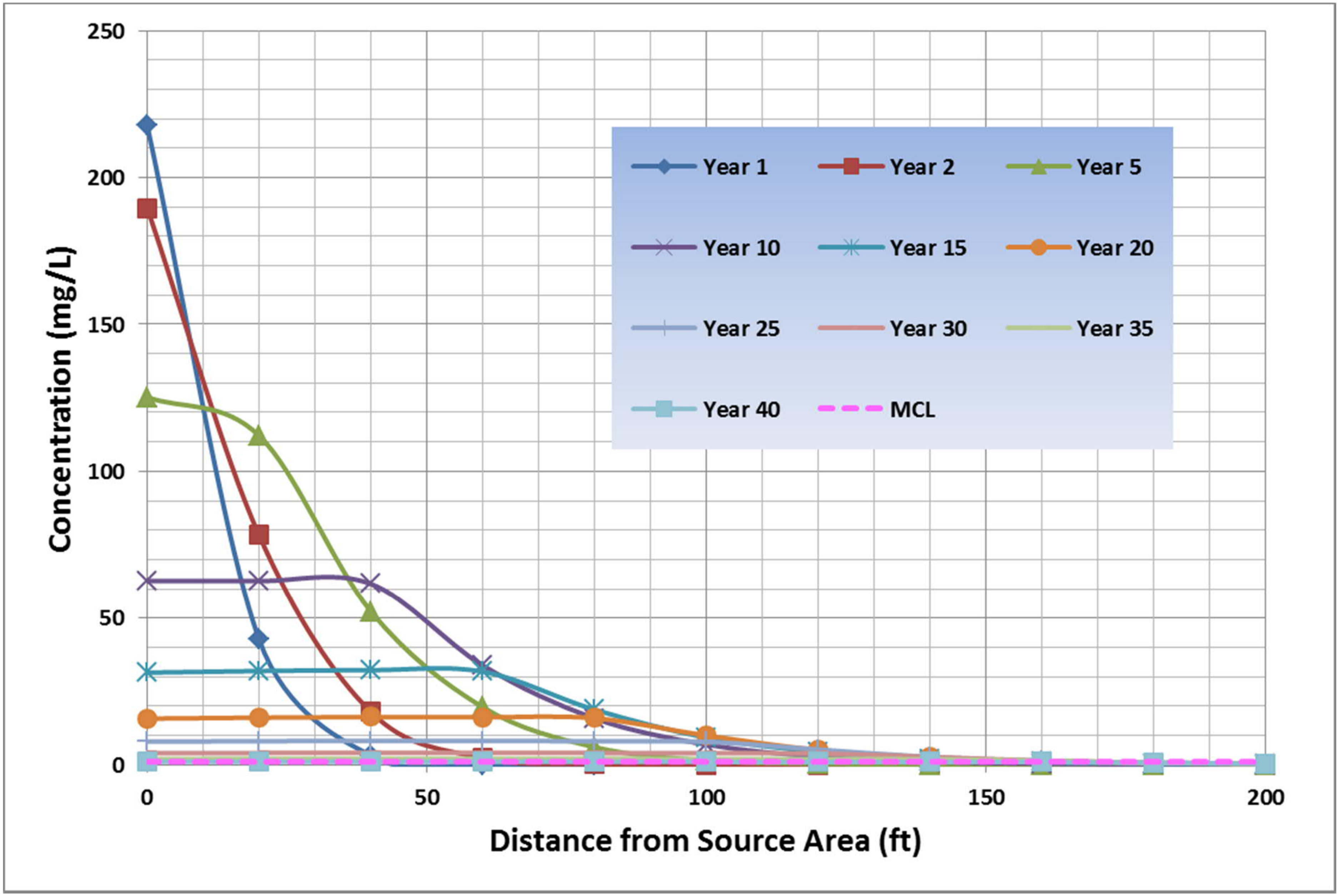

Figure 9-a: Modeled Toluene Concentrations along Plume Centerline: Sensitivity 2 (groundwater velocity is doubled) (Normal-scale)

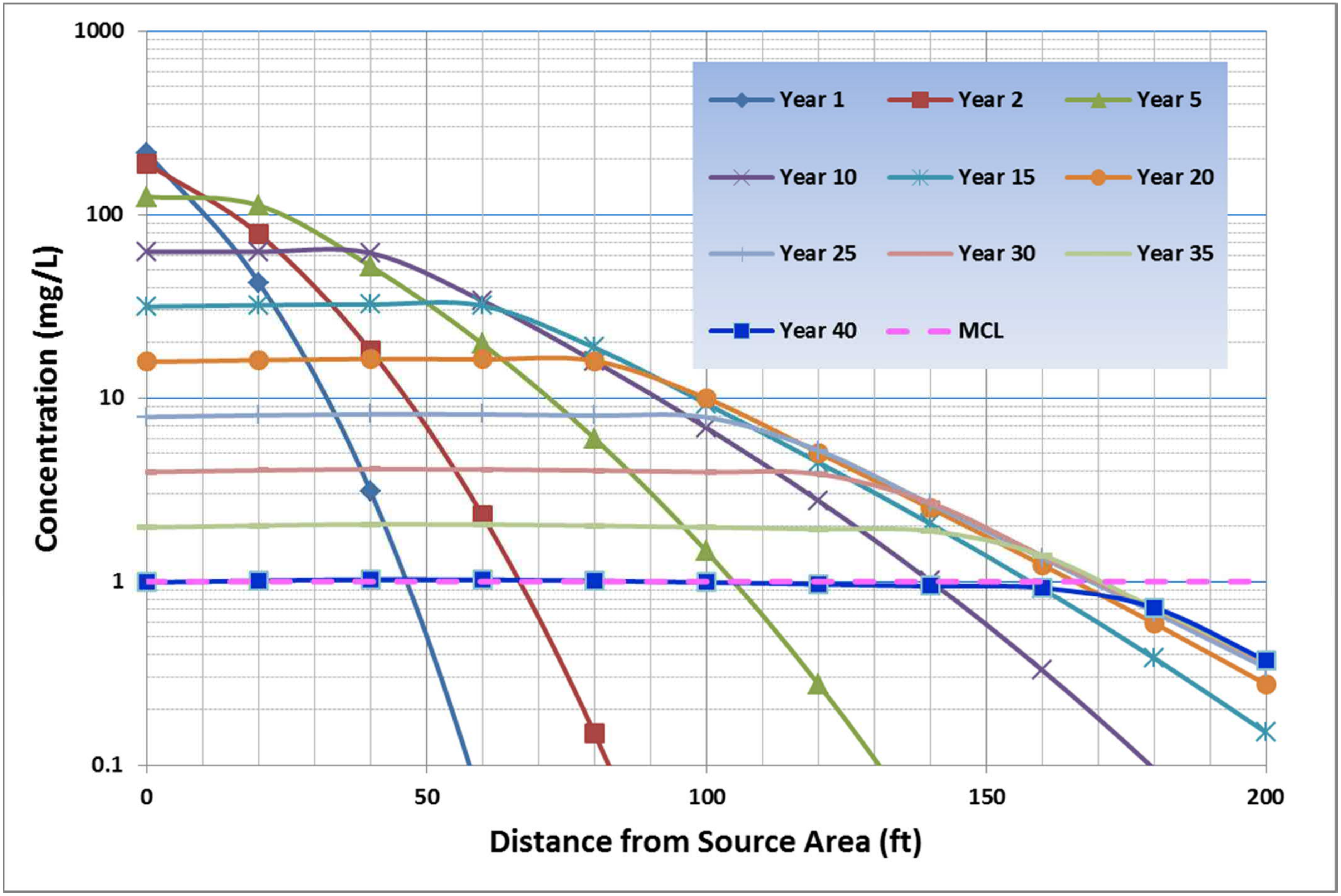

Figure 9-b: Modeled Toluene Concentrations along Plume Centerline: Sensitivity 2 (groundwater velocity is doubled) (Log-scale)